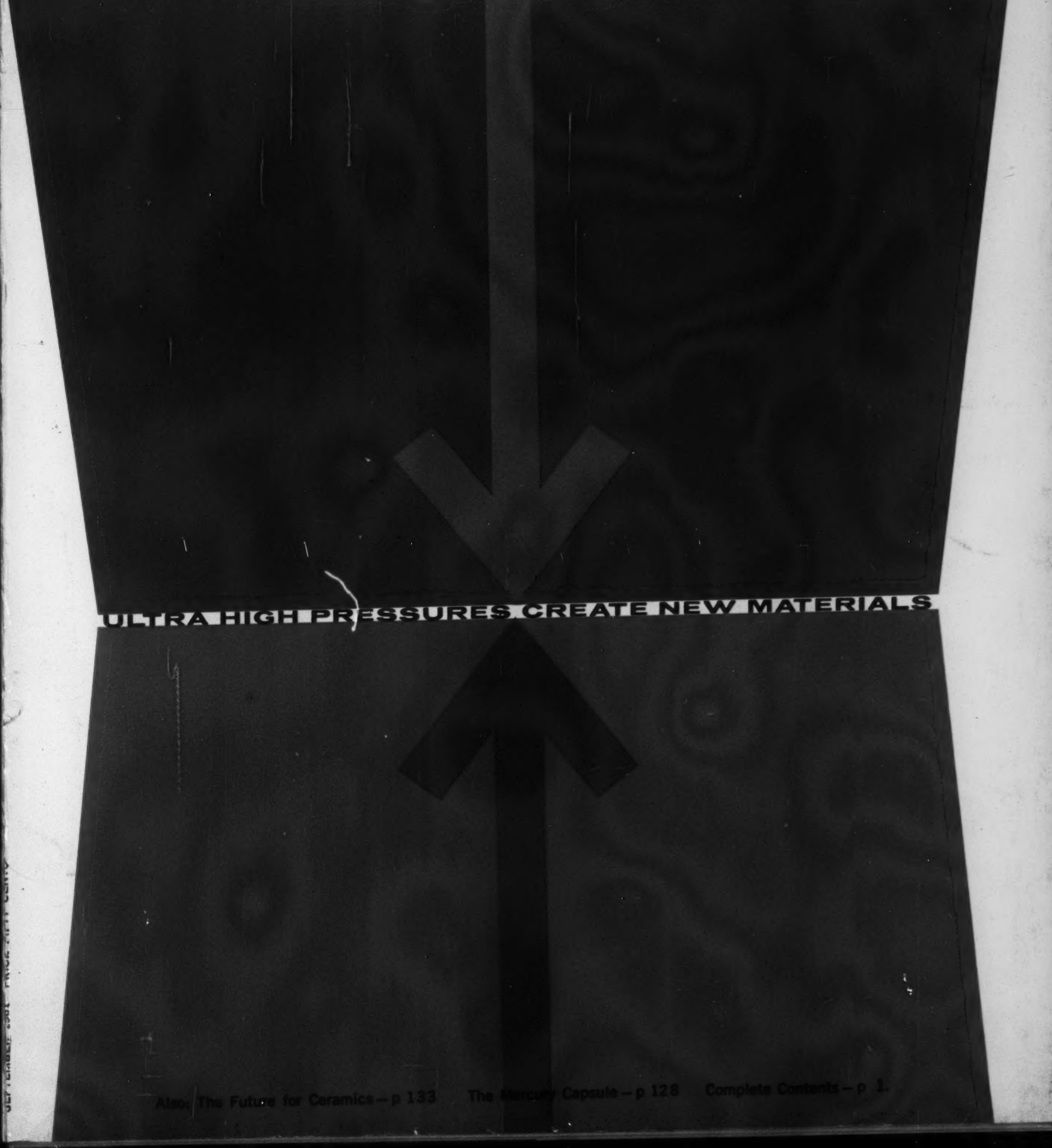
Materials

in Design Engineering



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Also: The Future for Ceramics — p 133   The Mercury Capsule — p 128   Complete Contents — p 1.

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Publication B-38 tells the story. Write for your copy—or for any assistance from our Metallurgical Dept. in selecting the proper alloys for your design problems. Address: Anaconda American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario. 61-1109

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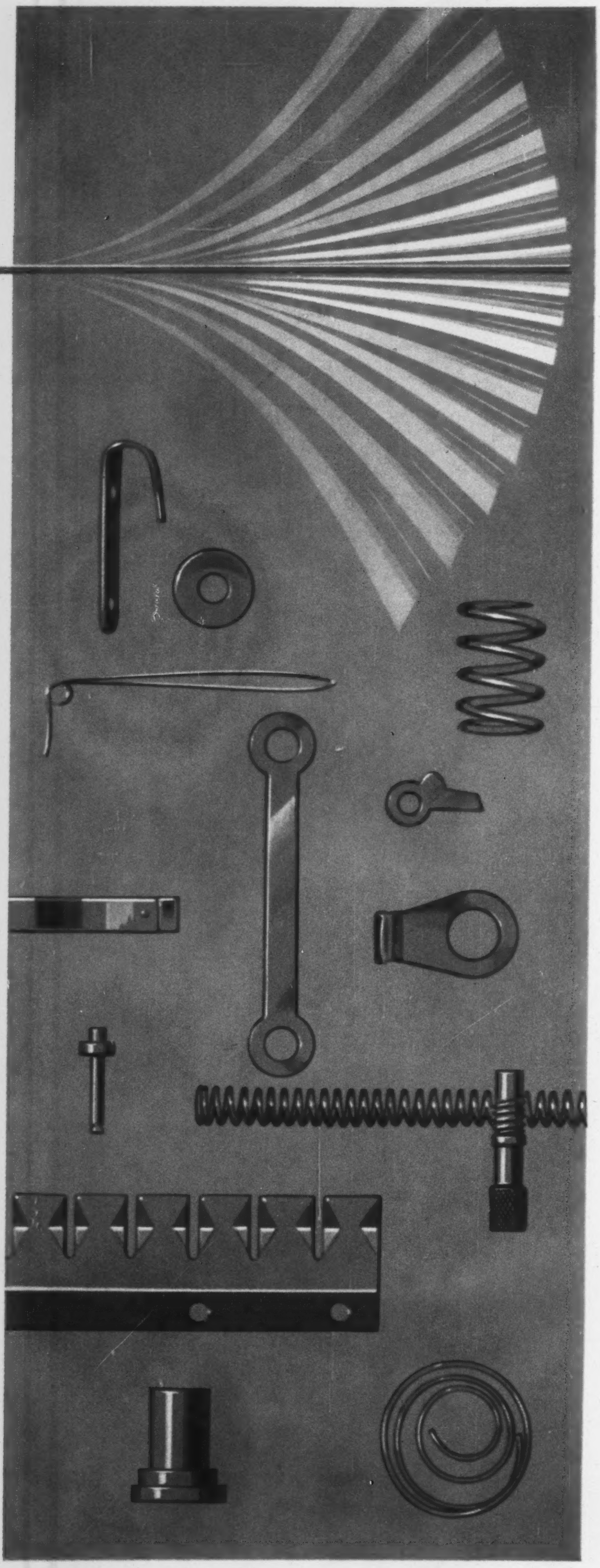

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SEPTEMBER, 1961 | VOL. 54, NO. 3

Materials
in Design Engineering®

FORMERLY MATERIALS & METHODS

APPLICATION OF METALS, NONMETALLICS, FORMS, FINISHES

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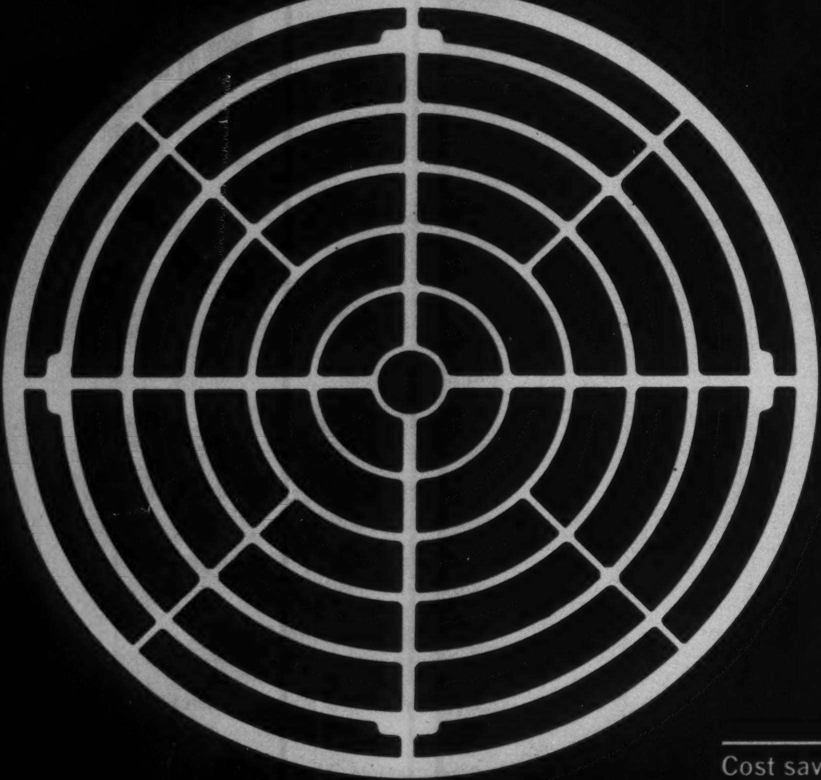

Cost saving: 33%

"are you getting your metal's worth?"

The intake tubes of the Waterous Company's model CMB fire pump suck in **1250** gallons of water a minute. Rocks and other foreign matter can get sucked in too—which would have disastrous effects on the pump. A screen is needed on the intake tubes, a screen that's tough and corrosion resistant, with extra-thin vanes and a smooth surface for unimpeded water flow.

Originally these screens were fabricated from sheet brass, with the vanes brazed together. An expensive material and method for a simple but important component. **Today these screens are die cast of Zamak at a cost saving of 33%** by Twin City Die Casting of Minneapolis. The tapered vanes have a minimum wall thickness of 1/32 of an inch. Zamak is the only die casting material that can fill these thin sections and still provide the strength, corrosion resistance and smooth "as cast" surface necessary.

To find out how you can put zinc die casting to work cutting your production costs, write today to The New Jersey Zinc Company for your set of Zamak technical data books detailing the properties, use, design techniques and machining practices of the Zamak alloys. Remember—Zamak gives you more for less. Are you getting your metal's worth?

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NEXT MONTH

New Ways to Strengthen Metals . . . Simple phase transformations obtained by quench and temper do not provide enough strength for many modern applications. Be sure to see this helpful review of the current status of dispersion hardening, ordering and other new approaches to strengthening metals.

High Temperature Insulations . . . A comprehensive status report on the new inorganic insulations used in potting, encapsulating, and on wire.

A New Torsion Tester . . . This kinetic device makes it possible to determine dynamic properties of very hard, "brittle" materials.

Flake Glass Reinforcement . . . What it can do for plastics that fiber cannot.

Protective Coatings . . . The new polyester types and their decorative and functional uses . . . Also, an itumescent coating that insulates metals from temperatures up to 2000 F and above.

***This Month's Cover** by Harry & Marion Zelenko.*

GENERAL ELECTRIC does. To produce thousands of these precise "dog pointers" on a lower cost basis they redesigned for powder metallurgy. Instead of a two-part item—which had to be machined, punch pressed, deburred, re-machined and press fit together—one punch of the compacting press at Dixon Sintaloy, Inc. does the job. Each one of the dog pointers pressed from brass powder meets tolerances of ± .001" on the diameter of the .061" hole and has the smooth, dense properties essential for plating. This is accomplished readily by GE to insure that the dog pointer matches the extra-long service life of the kilowatt-hour and other electric meters it is used in.

Think big—think powder metallurgy. For more information about the application, design techniques and properties of metal powder parts, write today to The New Jersey Zinc Company for your copy of "Designing For Pressed Brass and Nickel Silver Metal Powder Parts."

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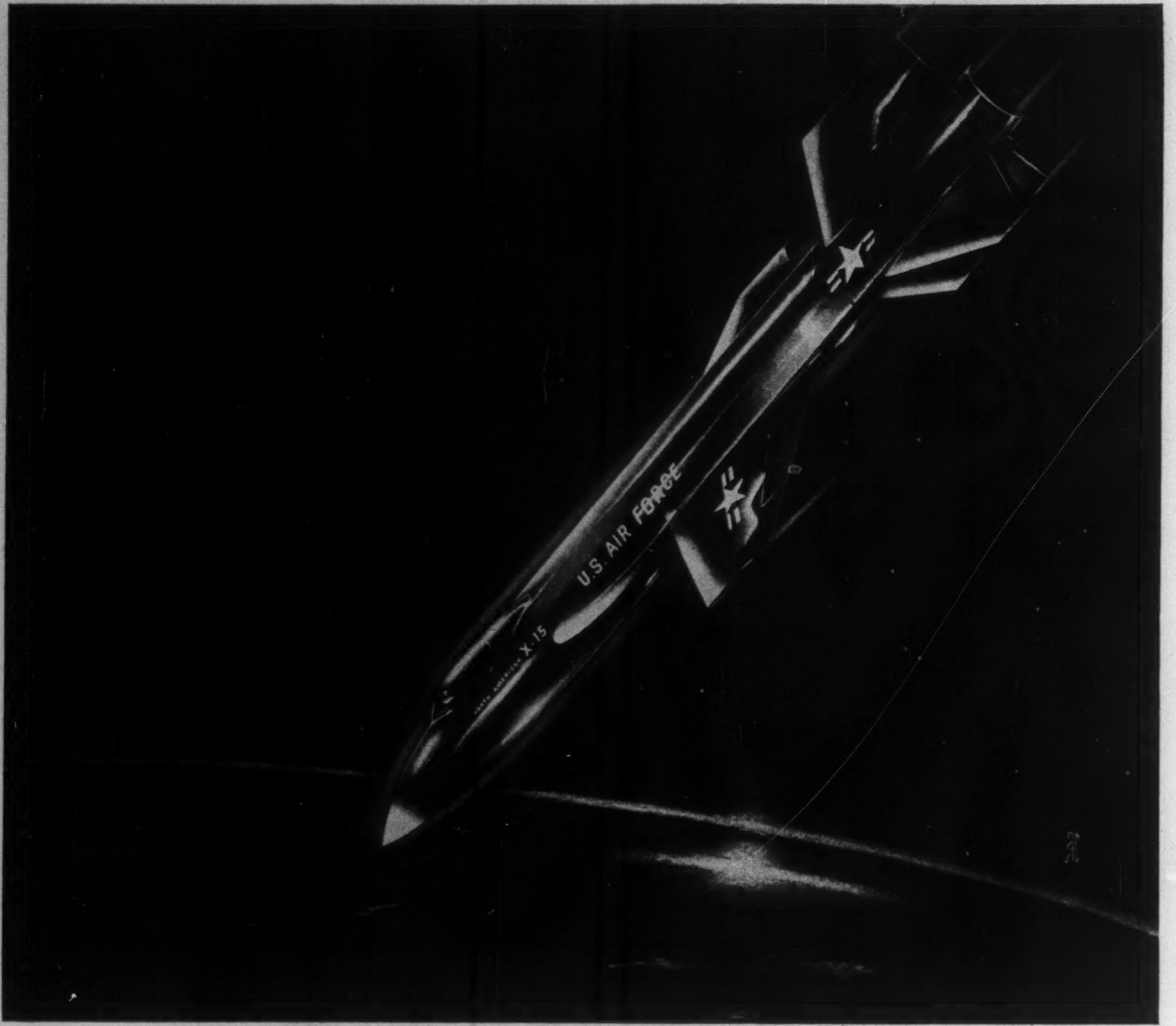

In test flight, the X-15, America's first manned space probe ship, has reached a speed of 3370 mph, and an altitude of 169,600 ft. Ship was built by North American Aviation, Inc.

How X-15 survives red-hot re-entry

When the latest pilot-controlled research rocket plane, X-15, streaks in from space to re-enter the earth's atmosphere, air friction heats its nose and leading edges to a blood red heat in seconds.

"Blood red heat" temperatures might easily weaken the skin of the X-15 . . . hopelessly soften, deform or destroy many other materials.

How could designers make it possible for X-15 and her pilot to return safely?

The answer was found in an age-hardenable nickel-chromium alloy. Developed by Inco research, it successfully withstands the destructive effect of intense heat. Even when red hot, it retains the strength which the X-15 needs to safely make its re-entry into the atmosphere.

High temperature properties, corrosion resistance, strength, elasticity, beauty . . . so many varied advantages can be achieved through the use of Nickel in metals.

If your business is metals, or if you use metals in your business, call on Inco for the latest information about how Nickel and its alloys can help you. *The International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y.*

INCO TRADE MARK **Inco Nickel**

NICKEL MAKES ALLOYS PERFORM BETTER LONGER

Sintered parts made of a new copper powder are said to have up to 90% of the electrical conductivity, elongation and tensile strength of solid copper parts; density ranges from 96 to 99%. Presently used copper powders containing organic binders reduce electrical conductivity quite severely. The new powder is expected on the market shortly.
Source: Fansteel Metallurgical Corp., North Chicago, Ill.

A high quality vinyl surfacing material for decorative and protective use over metal, wood, glass-reinforced polyester and other surfaces is flexible, easily bonded, durable, and resistant to fading and most stains. It is mold and mildew resistant, and has a flame spread rating of 20 when tested in accordance with ASTM E84-59T. It is sold in three embossed textures, 20 colors and two gages.
Source: Armstrong Cork Co., Industrial Div., Lancaster, Pa.

A new gold electroplate for electronic parts is said to be completely stress-free, ultra pure, satin bright, extremely ductile and tight grained. Tests show the 24-karat gold deposit withstands 60 min at 1000 F in air without discoloring. The gold, supplied as salts or as a solution, plates directly on stainless steel, monel and other alloys.
Source: Technic, Inc., P. O. Box 965, Providence, R.I.

A new ultra high strength steel can be heat treated to 360,000 psi tensile strength, 290,000 psi yield strength (0.2% offset), 20-30% reduction in area, and 6-8% elongation (in 2 in.) The steel is sold as bars, forgings, sheets, plates and wire, with a bar base price of $1.87 per lb. (More details next month.)
Source: Vanadium-Alloys Steel Co., Latrobe, Pa.

Low density, resilient silicone rubber foam can be produced at room temperature from an RTV silicone rubber compound now available. The foam can be used over the temperature range —100 to 500 F and has excellent electrical properties. It sells for $8 to $12 per lb.
Source: Dow Corning Corp., Midland, Mich.

Prealloyed heavy metal powders containing tungsten, nickel and copper are now available. The heavy constituent, tungsten, is in a matrix of copper-nickel alloy and cannot settle out of the suspension as often happens with mixed metal powders of tungsten, nickel and copper. The high density alloy powders are expected to be used in radioactive shields and in containers for radioactive materials.
Source: Astro-Alloys Corp., 100 S. Pearl St., Pearl River, N.Y.

A de-icing coating for plastics glazing materials is now in the final stages of development. The conductive coating, which can dissipate 4.5 w per sq in. maximum energy, is sandwiched in with a castable interlayer material in a three-ply acrylic

B.F.Goodrich

Here's Estane: a tough, abrasion-resistant polyurethane elastomer that is thermoplastic!

Speeds up molding and extrusion. With Estane, you can recycle waste and scrap stock accumulated in normal fabrication. Estane can be extruded, injection-molded, milled, calendered or used in solvent systems using standard thermoplastic processing techniques. Estane materials behave much like vinyl in processing—same equipment, similar settings. Estane polyurethane comes in tough, rubbery, clear granules, ranging in hardness from 65 to 95 Durometer "A". All have a tensile strength of over 5000 psi and an elongation over 500%. Fuel and oil-resistance, cut and tear-resistance, abrasion-resistance and low-temperature flexibility are all excellent.

Estane provides cost savings because of its unique properties and simplified handling procedures. Faster cycles and recycled processing scrap produced a demonstrated 50% cost reduction in one operation. Available polymers and compounds provide profit opportunities in many applications, such as shoe soles, heels and uppers; in elastic thread, for wire and cable jacket, tubing and hose, and many coating applications.

For information about the several Estane materials now available, write Department NN-7, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. In Canada: Kitchener, Ontario.

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Polyurethane Materials

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or polyester windshield. Optical qualities are said to be excellent, and de-icing performance is comparable to that previously obtained by sputtered coatings on glass.
Source: Goodyear Aircraft Corp., Akron, Ohio.

A new wood panel highly resistant to damage is made from three to five plies of hardboard. It has a smooth surface, high density and high internal bond strength, and can be sawed, drilled, grooved and shaped easily. A standard hardboard panel measures 4 by 8 ft and is sold in five thicknesses ranging from ½ to 1¼ in.
Source: Cascades Plywood Corp., Lebanite Div., Public Service Bldg., Portland 4, Ore.

Fast annealing of reactive metal strip can be done with a new electron beam furnace now available. A coil of tantalum, columbium, titanium or zirconium metal strip unwinds and feeds into the furnace, passes over an electron beam gun, then exits and rewinds at the other end of the furnace at speeds up to several thousand feet per minute. Annealing is done under high vacuum.
Source: Temescal Metallurgical Corp., 2850 7th St., Berkeley, Calif.

A machinable, cutting-grade carbide can be easily turned, drilled, milled, tapped and filed in the annealed, as-received condition; heat treated to Rockwell C70, it behaves like solid carbide. Service life in cutting hardened steels compares favorably with that of conventional carbides, which can be shaped only by diamond grinding. The new material is a composite of ultra hard carbide particles dispersed in a high speed steel matrix,
Source: Chromalloy Corp., Sintercast Div., 171 Western Hwy., West Nyack, N.Y.

A way to prevent weld spatter from sticking to metal surfaces is to use a new compound that contains no oils, varnishes or other volatile substances. A single, thin coating serves for a number of weld passes. Spatter in the treated area is wiped clean with a dry cloth after welding. The compound sells for $3.40 per gal.
Source: Cleanweld Products Co., 9220 S. Atlantic Blvd., South Gate, Calif.

A new thermal insulation is 'virtually pure carbon.' Available as fibers and as a fabric 32 in. wide by 50-75 yd long, the material is said to have extremely low thermal conductivity and a low ablation rate when combined with phenolic resins. Molded parts of 50% fiber and 50% phenolic resin (by weights) have a tensile strength of 8500 psi, flexural strength of 15,000 psi and compressive strength of 19,000 psi.
Source: H. I. Thompson Fiber Glass Co., 1733 Cordova St., Los Angeles 7.

Tungsten-molybdenum strip has been rolled directly from centrifugally cast material. Tungsten alloy strip is usually rolled from arc cast ingots which require a forging breakdown before rolling. In an experimental run, a 98% tungsten-2% molybdenum alloy was rolled from an as-cast thickness of 0.64 in. to a finished thickness of 0.035 in. without an intermediate anneal or recrystallization.
Source: Oregon Metallurgical Corp., Albany, Ore.

another torture test for leaded alloy

This guide bushing is a much abused part in a pneumatic rock drill—subjected to severe shock loads and a shattering type of vibrational stress. It is machined from a bar of lead-treated* Aristoloy 8620, carburized and hardened to a 58-63 Rockwell "C". When GARDNER-DENVER switched to lead-treated steel, they happily discovered production jumped 42%. Feed rates, drilling, turning, forming, boring, and cut-off operations could also be increased. Tool life was extended 20 pieces between grinds.

For complete information about how you can get alloy steel strength in free-machining steel, call your nearest Copperweld representative. Or write for Leaded Steels Catalog and Products & Facilities Catalog.

*Inland Ledloy License

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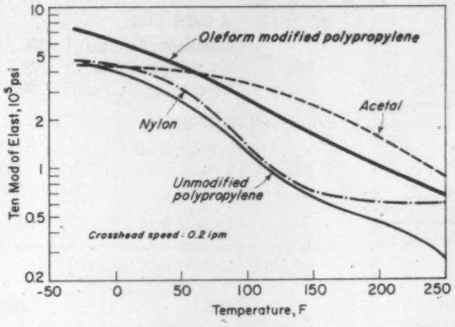


Modified Polypropylene Is Stiffer, Costs Less

by **Roger F. Jones,** *Research Chemist, AviSun Corp.*

HOW OLEFORM COMPARES WITH OTHER PLASTICS

Plastic ➡	ASTM ⬇	Polypropylene		Acetal	Nylon (type 6/6)	Phenolic (wood-flour filled)
		Oleform	Un-modified			
COST						
¢/Lb		36	42	65	98	22
¢/Cu In.		1.6	1.4	3.3	4.0	1.2
MECHANICAL PROPERTIES[a]						
Ten Yld Str, 1000 psi[b]	D638	4.5	5.0	9.8	8.5-9	7.5
Elong at Yld, %[b]	D638	6	20	10	60	<1
Ten Mod of Elast, 10^5 psi[c]	D638	2.9	1.55	3.75	1.75	10
Flex Mod of Elast, 10^5 psi[d]	D790	5.5	1.7	4.1	1.75	10
Izod Impact Str, ft-lb/in. notch	D256	1	1	1.5	2	0.5
PHYSICAL PROPERTIES						
Specific Gravity	D792	1.24	0.91	1.43	1.14	1.45
Heat Dist Temp, F						
66 Psi	D648	295	240	338	360-390	300
264 Psi	D648	205	150	212	150-170	275
Water Absorption (24 hr), %	D570	0.02	nil	0.12	1.5	0.6
Lin Coef of Ther Exp, 10^{-5} per °F	D696	2.1	6.7	4.5	5.5	2.1
Burning Rate		Slow	Slow	Slow	Self-ext	Self-ext
CHEMICAL RESISTANCE						
Acids		Exc	Exc	Attacked	Attacked	Good
Bases		Exc	Exc	Attacked	Exc	Attacked
Solvents		Good	Good	Exc	Good	Good
ELECTRICAL PROPERTIES						
Dielectric Str (short time; 125 mils), v/mil	D149	450	660	500	400	310
Dielectric Constant						
60 Cps	D150	2.75	2.2	—	4.6	7.0
1 Kc	D150	2.65	2.2	3.7	4.5	6.8
1 Mc	D150	2.60	2.1	3.7	3.5	5.5
Dissipation Factor						
60 Cps	D150	0.0074	0.0007	—	0.040	0.175
1 Kc	D150	0.0046	0.0002	0.004	0.040	0.120
1 Mc	D150	0.0019	0.0002	0.004	0.040	0.050
Loss Factor						
60 Cps	D150	0.020	0.0015	—	0.184	1.225
1 Kc	D150	0.012	0.0004	0.015	0.180	0.815
1 Mc	D150	0.005	0.004	0.015	0.140	0.275
Volume Resist, ohm-cm	D257	1.5×10^{15}	$>3 \times 10^{15}$	6×10^{14}	4×10^{14}	10^9—10^{13}
Arc Resistance, sec	D618	121	125	129	130-140	Tracks

[a] Injection molded specimens at room temperature.
[b] Crosshead speed is 1 ipm except where noted.
[c] Crosshead speed 0.2 ipm. [d] Crosshead speed 0.05 ipm.

■ The graphical comparison at left indicates why a new modified polypropylene may find wide use in applications requiring toughness and rigidity over a range of temperatures up to 250 F or above.

Trademarked Oleform, the plastic is available in experimental quantities from AviSun and carries an introductory price of 36¢ per lb, compared to 42¢ per lb for regular polypropylene. A fire retardant grade will be available soon.

For the most part modification consists of the addition of asbestos-type filler or reinforcement. The plastic can be processed about the same as unmodified polypropylene.

Oleform appears to be particularly promising for automotive parts, as well as parts for appliances, electrical and electronic components, and wiring devices. The economic benefits of injection molding may make the material competitive with many parts now made of compression molded thermosetting plastics.

Other properties compared

As the table indicates, Oleform has lower tensile strength than other plastics, but excellent rigidity and heat resistance together with a low coefficient of expansion. Water absorption is low and chemical resistance excellent.

The new material retains most of polypropylene's good dielectric characteristics. Dielectric constant and loss factor are particularly good in comparison with those of the other materials listed.

For more information, circle No. 600

These three steps give

Low Friction Coatings

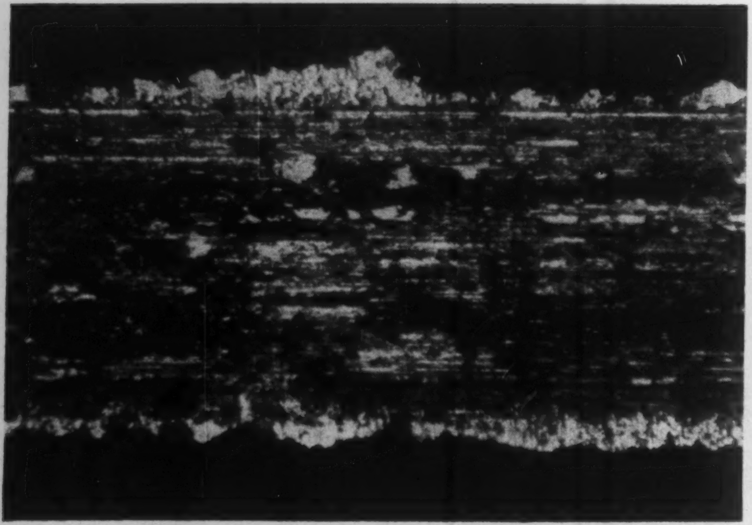
Durable, self-lubricating disulfide films are produced by converting molybdenum or tungsten electroplates at 400 F.

by J. E. Brophy, R. W. Ingraham and C. Pettus, *General Products Div., International Business Machines Corp.*

■ Low coefficients of friction and good wear properties can now be obtained by applying molybdenum and tungsten electroplates and converting them into compounds. The resulting films have better bond strength than conventional molybdenum disulfide lubricants and are more durable than many petroleum lubricants. Such coatings are particularly well suited for parts located in inaccessible areas where long lubrication life is needed.

MOLYBDENUM OVER STEEL		
1. Mix	Ammonium Formate	109.2 gm
	Molybdenum Oxide	25.2 gm
	Water	2000 ml
TUNGSTEN OVER STEEL		
1. Mix	$H_2WO_4 \cdot 2H_2O$	13 gm
	N_2H_4	13 gm
	Water	200 ml
2. Add (at 140 F)	Tartaric Acid	15 gm
	Glycine	7.5 gm
	Sulfuric Acid (97.1% by wt)	7 ml
	Water	200 ml
3. Add (at 140 F)	Pyrogallo [$C_6H_3(OH)_3$]	13 gm
	Water	200 ml
4. Add	Sulfurous Acid (SO2, 6.4% by wt)	18 ml
	Water	300 ml

1 Make up the plating solution. *Molybdenum solution is easy to prepare, tungsten bath more complex.*



Typical wear tracks *on solid lubricant surface (left) and 52100 steel ball (above) show no noticeable damage after 1000 sliding passes.*

Plate ➡	Molybdenum over Steel	Tungsten over Steel
Bath Temp, F	77	77
Current Density, amp/sq in.	1	1
Time, min	~ 3	~ 30
Thickness, mil	0.05 to ~ 0.1	0.5 to 1

2 Produce electroplates. *Molybdenum coating takes only 3 min; tungsten coating takes about 30 min.*

	Molybdenum to . . .		Tungsten to . . .	
Conversion ➡	Molybdenum Disulfide	Molybdenum Selenide	Tungsten Disulfide	Tungsten Selenide
Conversion Gas	Hydrogen sulfide (H_2S)	Hydrogen selenide (H_2Se)	Hydrogen sulfide (H_2S)	Hydrogen selenide (H_2Se)
Gas Pressure, psi	400	400	Atm	Atm
Temperature-Time	3 steps: 302 F—2 hr, 257 F—110 hr, 140 F—300 hr	302 F—24 hr	399 F—4 hr	399 F—4 hr
Coefficient of Friction				
1 Pass	0.05	0.08	0.06	0.08
1000 Passes	0.05	0.08	0.09	0.08

3 Convert surface. *Molybdenum coatings must be treated under pressure; tungsten at atmospheric pressure but a higher temperature.*

with Good Bond Strength

Although the coatings have been used mainly on conductive base metals such as steel and copper they can also be applied to nonmetallic parts that can withstand the relatively high processing temperature needed (400 F). However, no applications for nonmetallics have been tried as yet, primarily because conventional nonmetallics such as nylon and TFE fluorocarbon have good natural lubricating properties.

Structure produces lubricity

The molybdenum or tungsten films are electrodeposited over the substrate and then converted to lamellar solids of molybdenum or tungsten disulfide, selenide or telluride. These lamellar solids have a unique crystal structure consisting of crystal planes of metal and non-metal atoms. When crystal surfaces containing nonmetal atoms slide against each other the weak Van der Waal's force between the atoms results in low friction force and excellent wear properties.

Coefficients of friction of treated surfaces range from 0.05 to 0.08 (Table 3), depending on the number of cycles involved and whether a sulfide or selenide treatment is used. Studies on telluride surfaces are still in progress.

How process works

Tables 1 and 2 show typical bath compositions and conditions that have been successfully used to plate molybdenum and tungsten on carbon steel. The steel is first washed with distilled water and fluxed with benzene. Because of the low temperatures used the process does not produce any structural or geometric changes in the base material, and the coating is so thin that dimensions of finished parts can be held within ±0.5 mil.

Molybdenum-plated parts are washed and dried after plating and then placed in a special chamber. Hydrogen sulfide or selenide is introduced and the chamber sealed off. The chamber is heated to an appropriate temperature and held there for a set time (see Table 3 for schedules). Pressure of the gas during conversion is generally about 400 psi; it varies with the conversion temperature and can be controlled by adjusting initial gas pressure inside the chamber before heating.

Tungsten-plated parts require somewhat different treatment. After plating, they are washed in acetone, dried, and then converted by allowing hydrogen sulfide or selenide gas to flow continuously over the surfaces at 400 F for 4 hr.

Nonmetallics can be treated provided that: 1) surfaces are first coated with an evaporated conductive film and, 2) the melting point of the material is below the maximum processing temperature used to produce the lubricating surface (400 F max, as compared to a minimum of 1100° F for previous processes).

Permanent Magnet Has Highest Power

Directionally solidified alloy can cut magnet size by 15%.

■ The photograph below shows how the cast grain structure of a new, improved magnetic material called Alnicus differs from that of Alnico VB-DG. The improvement is achieved by directional solidification.

The process used to obtain the improved structure was developed by U. S. Magnet & Alloy Corp., 266 Glenwood Ave., Bloomfield, N. J., and is in full scale continuous production.

Higher energy available

The high energy product, $(BH)_{max}$, of Alnicus exceeds that of the available Alnico alloys.

Only platinum-cobalt alloys show comparable $(BH)_{max}$ values. These are not available commercially and cannot compete with Alnicus in cost.

The increase in energy product means that magnet size can now be reduced approximately 15%, size being inversely proportional to the energy product. U. S. Magnet claims that Alnicus is competitive in cost with the Alnicos when size reduction is considered.

Two grades are being produced:

USM 75: Maximum energy product, $(BH)_{max}$, is 7.5 million gauss-oersteds; residual induction, B_r is 13,900 gauss; and coercive force, H_c is 650 gauss.

USM 65: $(BH)_{max}$ is 6.5 million gauss-oersteds, B_r is 13,500 gauss and H_c is 650 gauss.

Density of both grades is 0.265 lb per cu in.

The $(BH)_{max}$ value of USM 75 exceeds that of Alnico VB-DG by 1,000,000 gauss-oersteds.

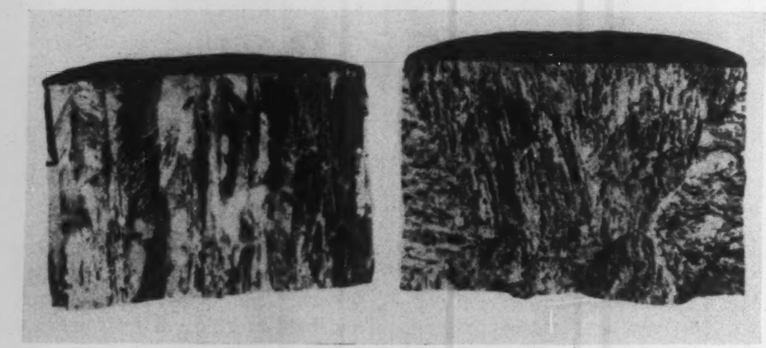
Many applications suggested

High energy magnets may eventually be used as field shaping devices for focusing and accelerating ions in propulsion units for space exploration and industrial applications.

More down-to-earth are these suggested applications: magnetic chucks, conveyors, holding and lifting devices, sensitive meters, electrocardiographs and encephalographs, outboard motor and lawn mower starting devices.

Quantities of Alnicus are already being used in magnetrons, very compact generators, magnetic separators, loudspeakers and radar equipment.

For more information, circle No. 602



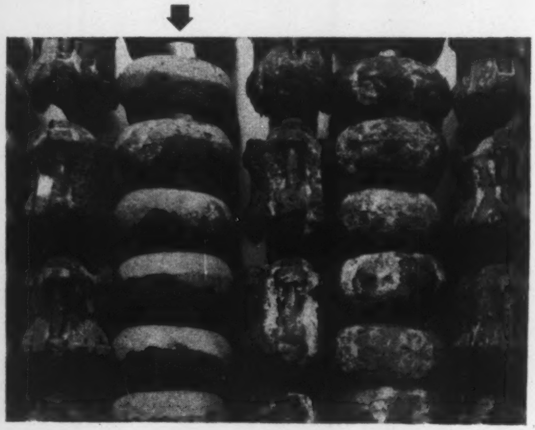
Directional *solidification of Alnicus USM 75 (left) compared to normal freezing pattern of Alnico VB-DG (right).*

Aluminum-Plastics Coating Resists Corrosion, Algae

■ The row of cooling coils indicated by arrow has been coated with a proprietary plastics compound containing up to 80% powdered aluminum. The coating, called Kolmetal, has prevented the salty river water coolant from corroding the coils for 2½ yr. Cooling efficiency has also been improved because the aluminum in the coating inhibits the growth of algae.

The severe corrosion caused by the river water, with an acid content of up to 5%, can be seen on the right set of coils which were installed at the same time but were not treated with the Emjay Maintenance Corp. coating.

For more information, circle No. 603



Thermocouple Alloy for 5000 F

Tungsten alloyed with 25% rhenium stays ductile after heating.

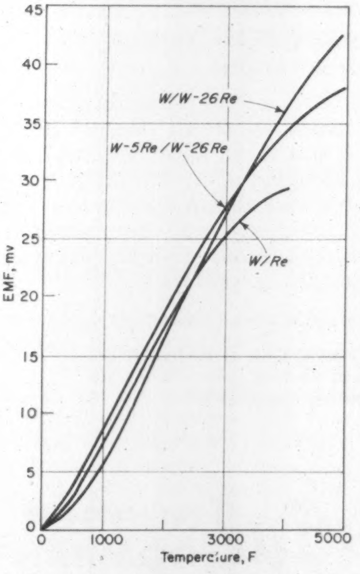
■ Temperatures up to 5000 F can now be measured with thermocouples using newly available tungsten–25% rhenium alloy wire (see Fig 1). The high strength alloy retains room temperature ductility after heating to temperatures as high as 3600 F.

Just announced by Chase Brass & Copper Co., Waterbury 20, Conn., the tungsten–25% rhenium alloy is now in commercial production.

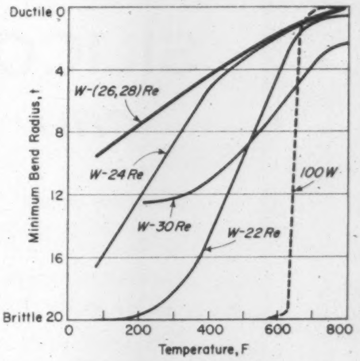
Old limit 3000 F

Temperature measurements with the commonly used platinum group thermocouples are presently limited to about 3000 F. Thus tungsten-rhenium thermocouple elements boost the limit by approximately 2000 °F.

Although optical pyrometers can be used at 5000 F, their size, the fact that they require visual access to the heated material, and the fact that they are not suited to automatic control place them at a disadvantage.



1 *Tungsten-rhenium thermocouples can measure temperatures up to 5000 F.*



2 *Adding rhenium lowers the ductile-to-brittle bend transition temperature of tungsten.*

More ductile than tungsten

The new alloy is much more ductile than tungsten. Improvement in bend ductility is indicated in Fig 2.

The reason for this increased ductility is rhenium's effect in lowering the ductile-to-brittle transition temperature. Tungsten is brittle at temperatures below approximately 625 F; the new tungsten-rhenium alloy retains its ductility down to room temperature.

Another advantage: the new alloy can be heated to higher temperatures than tungsten before it becomes "glass brittle" at room temperature. As the table shows, tungsten cannot be heated above 2200 F without paying this penalty. But tungsten–25% rhenium can be heated to 2900 F without serious loss, and usable room temperature ductility is retained even after heating to 3600 F.

This improved ductility, together with improved thermal shock resistance, is being used now in electronic tube components, principally support grids and heaters.

Despite its ductility, the wire is strong. After cold drawing 65%, room temperature tensile strength was 400,000 psi, elongation 2%, and the wire could be wrapped around a mandrel of its own diameter. Annealing at 3000 F reduced tensile strength to 245,000 psi, increased elongation to 15%, and did not change bend ductility.

Wire, strip available

Wrought tungsten–rhenium alloys are produced from pressed and sintered bars. These bars are warm swaged to approx. 0.1-in. dia and warm drawn to the desired wire sizes. Sintered bars are similarly worked to produce strip.

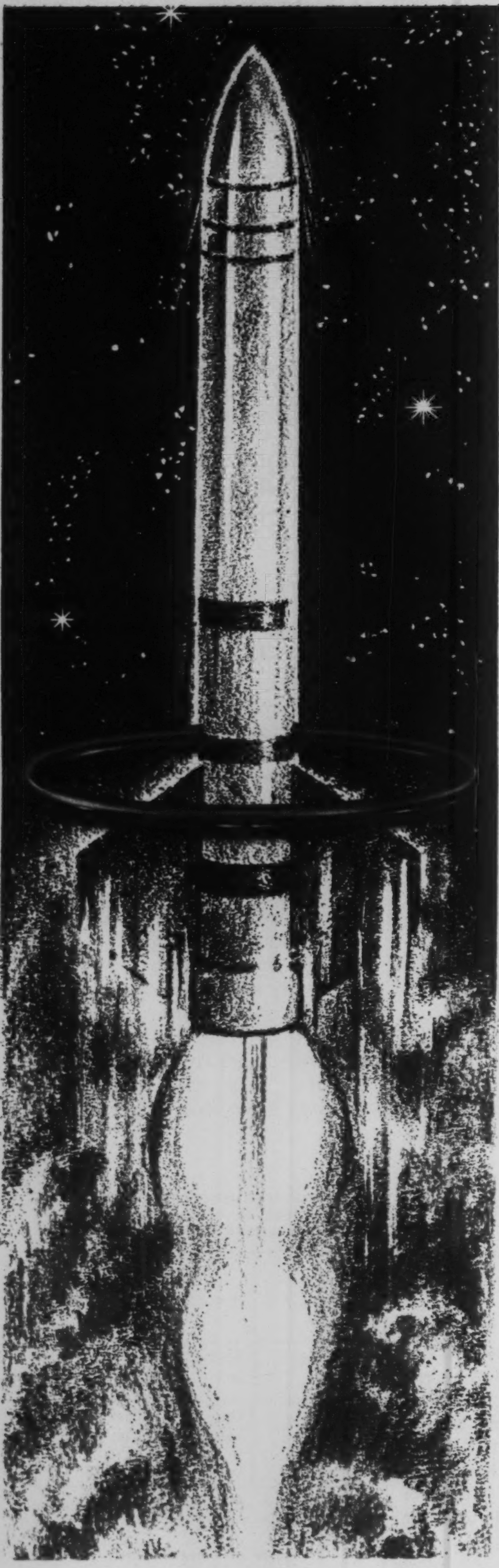
Sizes currently available in rod and wire range from 0.003 to 0.10 in. dia. Strip sizes range from 0.001 to 0.060 in. thk up to 4 in. wide.

ROOM TEMPERATURE BEND DUCTILITY OF 75W–25 Re AND PURE TUNGSTEN AFTER ANNEALING

Anneal Temp, F ↓	75 W–25 Re	Tungsten
As Drawn	Approx 2t[a]	1t
1800	2t	1t
2200	1t	2t to glass brittle
2500	½t	Glass brittle
2900	½t	Glass brittle
3300	3t	—
3600	5t	—

[a] t is ratio of smallest bend dia to wire dia (0.020 in. for ductile bends.)

For more information, circle No. 604



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- **FUNGUS GROWTH RESISTANCE**
- **DIELECTRIC PROPERTIES (as required)**
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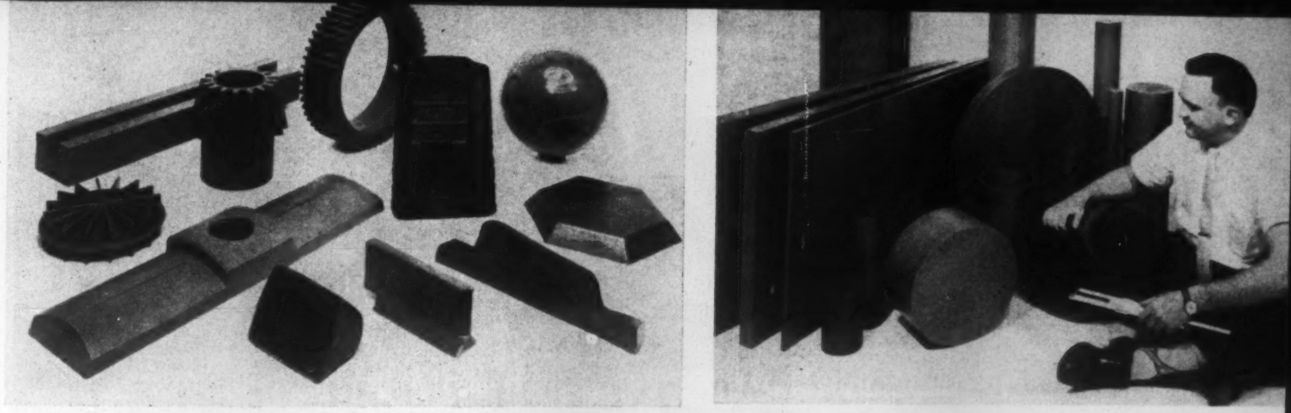

Complex custom parts, *as well as standard mill shapes, are now available in large sizes*

Large Nylon Parts

produced economically by monomer casting process

■ The table at left highlights the newly developed "monomer casting" process. In brief, the process permits low cost production of large, complex nylon shapes by techniques similar to those used for casting of metals.

Essentially, the process consists of casting liquid type 6 nylon monomer (E caprolactam) directly into a mold where it is catalyzed and polymerized to the final shape under atmospheric pressure.

Casting directly from monomer bypasses the conventional thermoplastic compounding steps, wherein monomer is polymerized, extruded and chopped to form a compound that can be formed by molding or extrusion techniques.

Thus, the raw material becomes a 46¢-per-lb monomer rather than a 98¢-per-lb molding compound. According to the producers, this lower cost can put monomer cast nylon into the medium priced resin class.

The lack of pressure in the casting process permits use of extremely low cost molds. For example, cost of an injection mold for a large 7-lb part might be $5000 or more. For MC nylon, a

(continued on p 173)

TABLE 1—COMPARISON OF NYLON CONVERSION PROCESSES[a]

Process ➡	**Monomer Casting**	Injection Molding	Extrusion Molding	Extrusion	Centrifugal Casting
Mold Pressure Requirements, psi	**Atmospheric**	20,000	100-300	100-300	100-300[c]
Maximum Part Weight, lb[b]	**Unlimited**	5-7	300	Not applicable	200-400
Maximum Thickness, in.	**Unlimited**	¾-1½	3-4	4	2
Price, $/lb[d]	**3.00-5.00**[f]	1.50-3.50	4-13	3-5	4-6
Production Rate, lb/hr	**800**	50-300	30	30-40	1-8[e]
Limitations	**Uneconomical for small parts**	Unsuitable for large parts	Low production rate	Low production rate	Low production rate; symmetrical parts only

[a] These data must be considered only as a guide. Special design and volume requirements or equipment variations can place the values beyond the stated limits. [b] Approx current limits. [c] G's. [d] Normal ranges in July '61. [e] Hours cycle per mold. [f] At current introductory costs; ultimately cost range will be $1.25-2.00.

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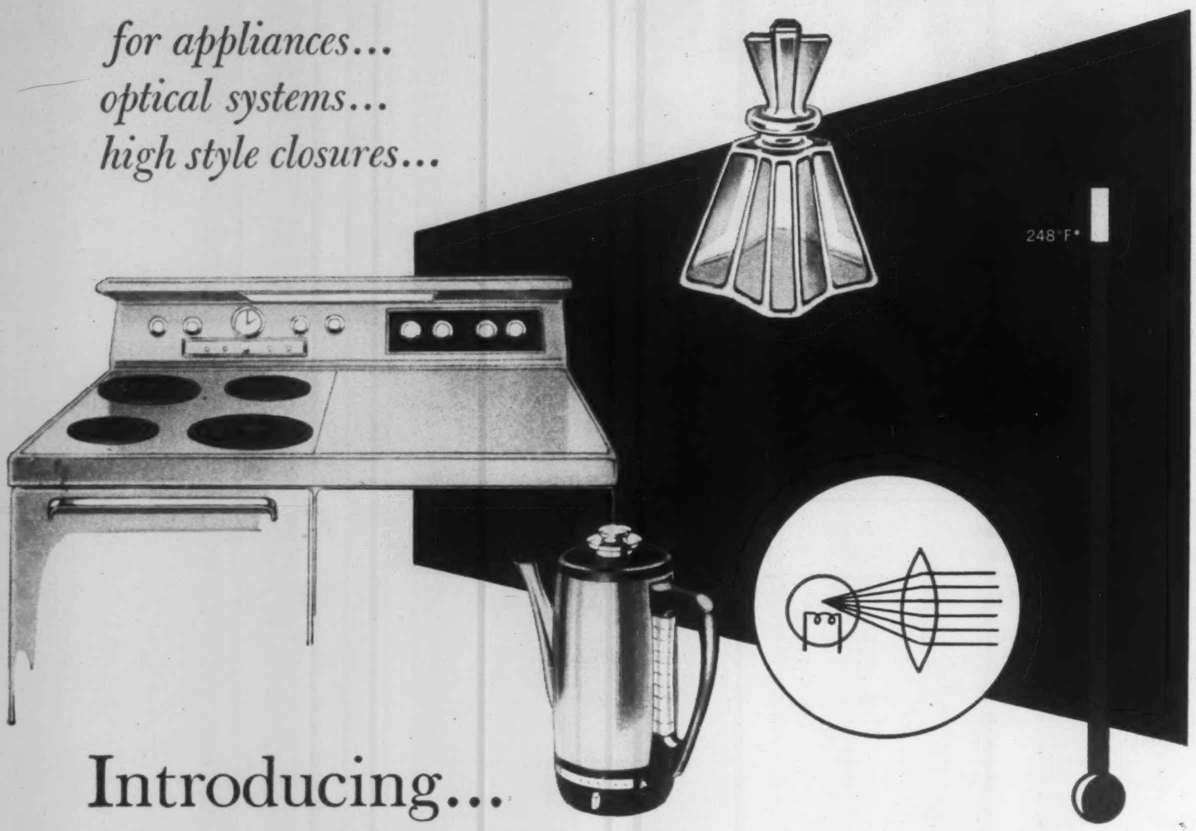

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BAVICK-11 has the highest heat and solvent resistance of any clear plastic, and is the *only* acrylic-type thermoplastic with the unique combination of properties listed above. If you need one of the first three properties—plus one of the last two—you will find Bavick-11 offers unprecedented advantages for the design and manufacture of parts of appliances and lenses that are exposed to high temperatures... for the stoppers of perfume bottles... and for many other applications.

Bavick-11 is ideal for sparkling backsplashes and gleaming trim on ranges, for pointers and crystal clear dial faces, for "piping" light, for use on electric percolators and skillets, dishwashers, washers and dryers, etc. Bavick-11 does not warp at temperatures that cause all other water-white transparent thermoplastics to soften and sag, nor does it craze from extreme thermal shock. Transparency is unaffected by continuous immersion in boiling water; shape is unaffected by low pressure steam. Medical and drug sundries made from Bavick-11 are clear and clean in appearance and can be sterilized in boiling water.

The stoppers of perfume bottles made of Bavick-11 combine jewel-like sparkle, with low cost and resistance to solvents and essential oils. Bavick-11 is unaffected by most acids and alkalies, alcohols, silicones and hydrocarbons. As a replacement for glass in certain optical systems, Bavick-11 offers high heat and thermal shock resistance, excellent optical properties, high index of refraction and comparative ease of fabrication. Bavick-11 is strong and tough... can be injection or compression molded, extruded, machined and cemented ... is easily colored, decorated, metallized, lacquered and printed.

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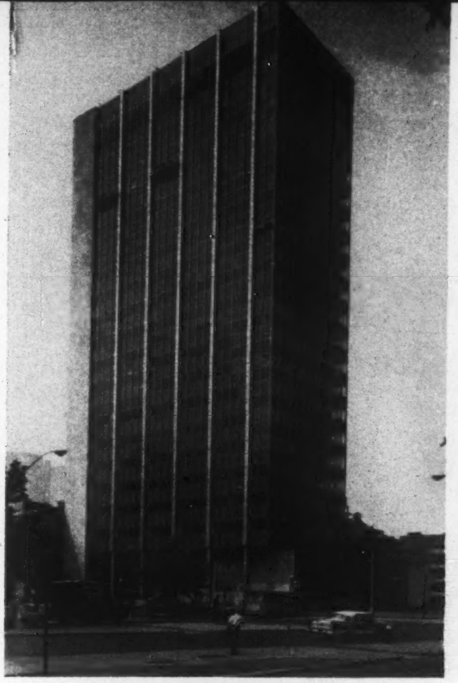

The new Engineering Center as it neared completion last month.

News OF INDUSTRY

Engineering Center Opens; Houses 19 Organizations

■ The new Engineering Center in New York City became an operating reality effective the beginning of this month.

The new building, which is located at 345 East 47th Street, New York City 17, now houses 19 separate engineering societies and organizations, according to Steven Marras, secretary of United Engineering Trustees, Inc., the organization that raised funds for the building.

The occupants are: American Society of Civil Engineers, American Institute of Mining, Metallurgical and Petroleum Engineers, American Society of Mechanical Engineers, American Institute of Electrical Engineers, American Institute of Chemical Engineers, American Society of Heating, Refrigerating & Air Conditioning Engineers, Illuminating Engineering Society, American Institute of Consulting Engineers, American Welding Society, American Institute of Industrial Engineers, Society of Women Engineers, Municipal Engineers of the City of New York, Engineers' Council for Professional Development, Engineers' Joint Council, Engineering Societies Library, Engineering Foundation, Welding Research Council, and Engineering Index.

Metal Show Coming

A "Materials Application Center" will be the heart of the 1961 Metal Exposition, sponsored by the American Society for Metals.

This educational feature will be the center of a total of 275 exhibits in the new Cobo Hall in Detroit, Oct 23-27. Concurrent with the show, ASM and nine other societies will present 68 technical sessions, many of them concerning new engineering materials and processes.

A detailed outline of the show and the National Metals Congress will be presented in next month's issue of M/DE.

Republic to Study Advanced Processes

A variety of advanced processing equipment has been installed in a new manufacturing research facility just completed by Republic Aviation Corp. in Farmingdale, L. I.

The laboratory was developed in connection with Republic's aerospace program. Equipment includes such things as a tungsten inert-gas welder, capacitor discharge forming equipment, and beryllium processing facilities.

Other new laboratories:

- Construction of a new $104 million research center for the National Bureau of Standards has begun on a 555-acre site at Gaithersburg, Md., signalling the first step in a complete relocation of the bureau from Washington, D. C.
- A gamma irradiation facility, using a 3000-curie cobalt-60 source, will be constructed at the University of Maryland to study radiation effects on plastics. Installation will be completed this year.

Meetings on Adhesives, Rapid Testing Set

A military-sponsored program on adhesives is one of three important symposia that independent organizations will sponsor in the next two months.

- "Modern Structural Adhesives Technology" will be the

MEMO

TO– *All spray phosphating engineers*

SUBJECT– *Precleaning eliminated*

Northwest's Interlox Spray Process now assures high efficiency phosphate coatings, without precleaning, even at low temperatures.

The Interlox Spray Process has proved its superiority through more than three years of research, two years of field testing, in over 100 production installations on everything from auto parts and metal furniture to lighting fixtures and scientific instruments.

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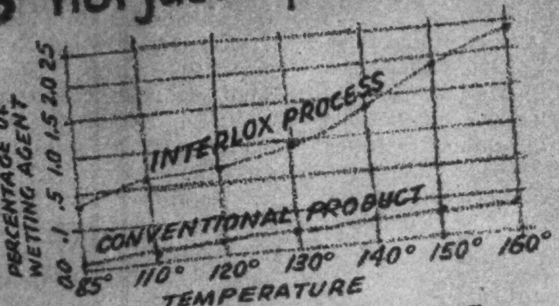

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topic at Picatinny Arsenal, Sept 27-28. This symposium, planned for a group of engineers selected from defense agencies and from industry, will emphasize joint design considerations, selection of proper adhesives, the bonding of reinforced plastics, and high temperature applications.

▶ The Second Rare Earth Conference will be held in Glenwood Springs, Colo., Sept 24-27. More detailed information may be obtained from J. F. Nachman, Denver Research Inst., University of Denver, Denver, Colo.

▶ The third annual symposium on High-Speed Testing, sponsored by Plas-Tech Equipment Corp., will be held in Boston, Oct 26-27. Program information is available from Ross H. Supnik, Plas-Tech Equipment Corp., 4 Mercer Rd., Natick, Mass.

Group to Standardize Filament Winding Tests

A task group is hard at work on the problem of establishing standard test methods for filament wound materials.

This group, created within Committee D-20 on Plastics of the American Society for Testing Materials, has begun a series of repetitive tests that will include many different methods. These efforts are directed toward establishing the test methods that will best provide for data comparison throughout the industry, and for more reliable test interpretation.

(The special requirements of filament winding tests are discussed in M/DE, Aug '60, pp 127-146.)

Aluminum Extrusions to Win Awards

An ingenious extrusion, or an ingenious part made from an extrusion, may win you an award from The Aluminum Assn. The association will give an award for an aluminum design in each of these categories, and a trophy to the company that nominates each winner.

The entry deadline is Sept 29. Details and entry forms may be obtained from the Awards Committee, The Aluminum Assn., 420 Lexington Ave., New York 17.

Materials Processing Seminars Start Soon

A variety of modern manufacturing techniques will be presented in a series of two-day seminars beginning this month.

The programs, listed below, are offered by the American Society of Tool and Manufacturing Engineers. The fees are $45 for ASTME members, $60 for nonmembers. Gilbert E. Seeley, ASTME Headquarters, 10700 Puritan, Detroit 38, Mich., has further information.

High Energy Rate Forming—Detroit, Sept 27-28; Denver, Apr 11-12.

Manufacturing with Space Age Metals—Philadelphia, Oct 10-11.

Prototype and Short Run Tooling Methods—New York City, Nov 8-9; Charlotte, N. C., Jan 23-24; Dallas, Mar 7-8.

Electric Machining and Forming—Hartford, Conn., Dec 6-7.

Die Design and Press Tooling—Hartford, Conn., Feb 7-8.

Automatic Production—Numerical Control—Cleveland, Feb 27-28.

Carbide and Ceramic Tooling—Chicago, Mar 28-29.

Process Planning and Reliability—Cleveland, May 7-8.

News of Societies

American Welding Society has awarded Dr. N. N. Rykalin, of the USSR Academy of Science, the Educational Lecturer Certificate Award for outstanding contributions to the Society.

Copper & Brass Research Assn. has elected the following officers: re-elected president —G. P. Bakken, Chase Brass & Copper Co., Inc.; senior vice-president—E. P. Dunlaevy, Phelps Dodge Copper Prod. Corp.; treasurer—F. L. Riggin, Sr., Mueller Brass Co.; secretary —C. H. Pihl.

Drop Forging Assn. has elected the following officers: president—William A. Carlile, Jr., Columbus Bolt & Forging Co.; vice-president—Walter H. Stocking, Pittsburgh Forgings Co.

Fourth International Plansee Seminar has awarded Dr. John T. Norton, Dept. of Metallurgy, Massachusetts Institute of Technology, the Plansee Plaque Award in recognition of his contributions in powder metallurgy.

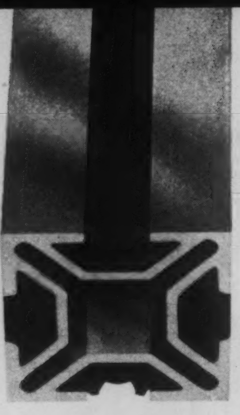
Institute of Environmental Sciences has elected the following officers: president—A. B. Billett, Vickers Inc.; executive vice-president—D. J. Fox, Fenwal Inc.; executive secretary—H. Sander.

Research Council on Riveted and Bolted Structural Joints has elected as chairman Richard B. Belford, technical advisor, Industrial Fasteners Institute.

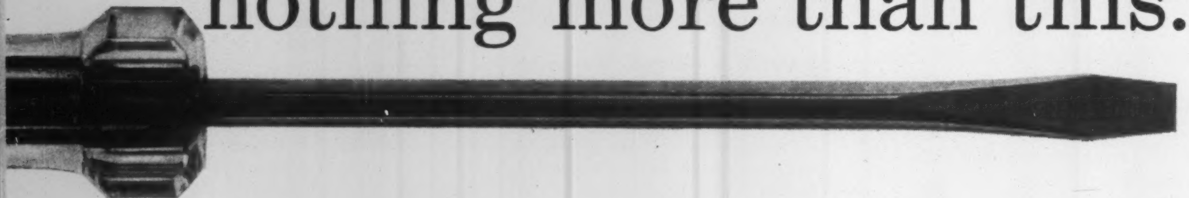
National Electrical Manufacturing Assn., Insulating Materials Div., has elected the following officers: chairman—E. R. Perry, National Vulcanized Fibre Co.; vice-chairman—D. J. O'Connor, Jr., Formica Corp. and R. L. Westbee, Minnesota Mining & Mfg. Co.

National Society of Professional Engineers has elected the following officers: president —Murray A. Wilson, consulting engineer; treasurer—Russell B. Allen, assistant dean of engineering, University of Maryland.

Standards Engineers Society has elected the following officers: president—H. R. Terhune, International Telephone & Telegraph Corp.; vice-president—K. W. Truhn, Bendix Aviation Corp.; secretary—R. F. Franciose, General Electric Co.; treasurer — E. Woerter, American Machine & Foundry Co.



Because of this extrusion, engineered with Olin Aluminum, 15 floors of the TIME-LIFE building in New York City can be quickly re-shaped with nothing more than this:



Olin engineers helped design this unique extrusion to serve as the universal junction of movable wall panels. The genius of this extrusion makes it possible to change office size, shape and color in jig time with nothing more than a screwdriver! So many Olin ideas like this have saved so much time and money for fabricators, designers and architects that modesty forbids telling all. As versatile as aluminum is, it doesn't think, doesn't create designs, or doesn't fabricate itself. That's why Olin Aluminum offers you the services of its marketing and technical staff. They "think aluminum." Don't you think it would be a good idea to call Olin?

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Coming Meetings

Engineering Management Conference, American Society of Mechanical Engineers and American Institute of Electrical Engineers. New York City. Sept 14-15.

Standards Engineers Society, Inc., 10th annual meeting. Chicago. Sept 18-20.

High Temperature Ceramic-on-Metal Processes Conference, American Ceramic Society. Columbus, Ohio. Sept 20-23.

Steel Founders' Society of America, 59th fall meeting. Hot Springs, Ark. Sept 24-26.

Pressed Metal Institute, annual meeting. Point Clear, Ala. Sept 24-28.

American Welding Society, fall meeting. Dallas. Sept 25-28.

Process Industries Conference, American Society of Mechanical Engineers. Houston. Oct 4-6.

Conference on Plastics Foams, Society of Plastics Engineers, Inc., Buffalo Section. Niagara Falls, N.Y. Oct 5.

American Standard Assn., 12th national conference. Houston. Oct 10-12.

Magnesium Assn., 17th annual conference. New York City. Oct 16-18.

2nd International Congress on Vacuum Technology, American Vacuum Society Inc. Washington, D. C. Oct 16-19.

American Society for Quality Control, 16th midwest conference. St. Louis. Oct 19-20.

Abrasive Grain Assn., fall meeting. New York City. Oct 23-25.

Metallurgical Society, AIME, fall meeting. Detroit. Oct 23-26.

43rd Metal Congress and Exposition, American Society for Metals. Detroit. Oct 23-27.

American Society of Tool and Manufacturing Engineers, semi-annual engineering conference. Toronto. Oct 26-27.

American Nuclear Society, 9th Hot Laboratory and Equipment Conference. Chicago. Nov 6.

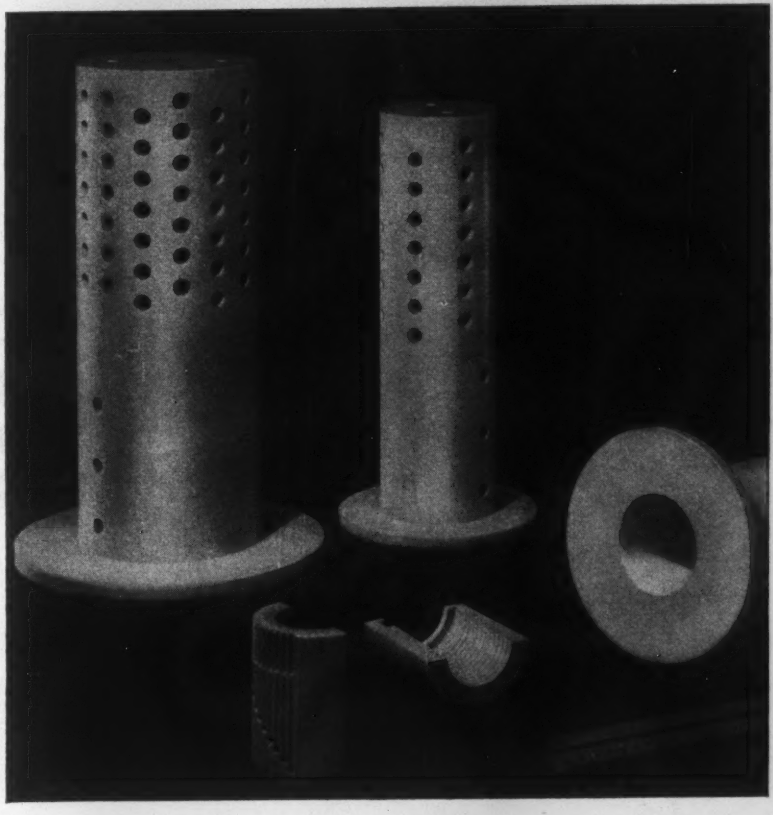
Steel Founders' Society of America, 16th annual technical & operating conference. Cleveland. Nov 13-15.

7th Annual Conference on Magnetism and Magnetic Materials, American Institute of Electrical Engineers. Phoenix, Ariz. Nov 13-16.

Symposium on Ceramics and Composites, Coatings and Solid Bodies, Society of Aerospace Material and Process Engineers. Dayton, Ohio. Nov 14-15.

American Society of Mechanical Engineers, winter meeting. New York City. Nov 26-Dec 1.

Look what R/M is doing with TEFLON*



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Letters to the editor

Cryogenics: aluminum vs nickel steel

To the Editor:

You are to be congratulated on the comprehensive and interesting special report on cryogenics ("The Role of Materials in Cryogenics," M/DE, July '61, p 107). It is indeed unusual to find so much information in one package on the various aspects of this increasingly important field.

However, the statement that "Table 6 compares the relative cost of tanks made from aluminum alloys, stainless steel and ASTM A353" is rather misleading. Actually, the table covers the relative cost of *material* only, and not the full cost of a completed tank, including the very substantial cost of fabrication—which is greater for ASTM A353 (9% nickel steel) than it is for aluminum.

We have made extensive fabricated-cost studies to develop final cost data in comparing cryogenic tanks made from 9% nickel steel and 5083–0 aluminum alloy. Two actual jobs, one shop-fabricated and one field-erected, have been compared. In these studies, we have based the aluminum materials cost on an average price of 58¢ per lb, which is a truer figure than the 60¢ price cited in Table 6.

The studies show that shop-fabricated tanks are very close in cost, but that field-erected tanks are substantially less costly in aluminum.

We will be glad to make our comparative study reports available to anyone interested in them.

DAN R. CHEYNEY
Manager
Industrial Sales Engineering
Kaiser Aluminum & Chemical Sales, Inc.
Oakland, Calif.

Pressure vessel steel

To the Editor:

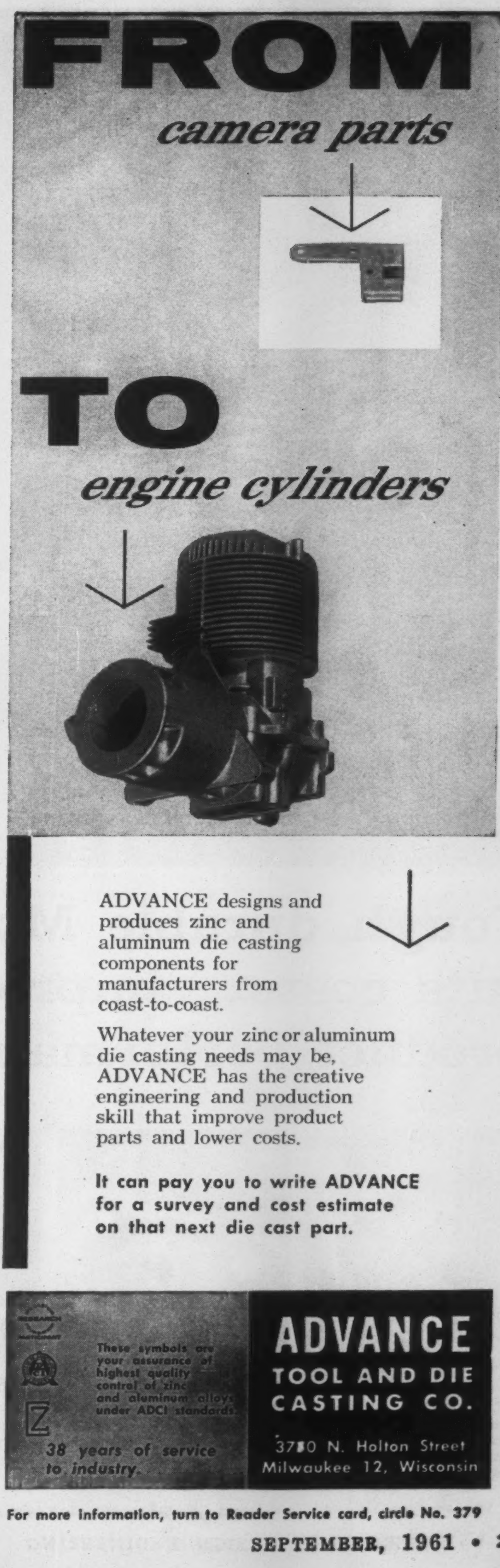
We would like to point out that you overlooked us in your article on "High Strength Steel for Pressure Vessels" (M/DE, July '61, p 154). Our SSS-100 has also been approved for use in welded pressure vessels.

ROBERT WHITE
Manager Alloy Sales
Sheffield Div.
Armco Steel Corp.
Houston, Tex.

M/DE manuals win approval

To the Editor:

Would you please advise me whether or not the technical manuals have been bound into one volume. I find them quite valuable and interesting, but I would prefer to have them also in a separately bound and indexed volume. Such volumes at reduced prices



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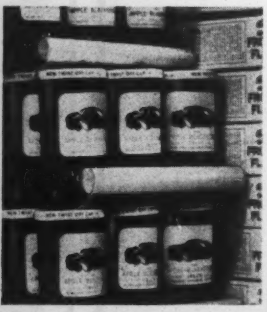

3. Roll-back shelving of "Mylar" gets rid of retail stacking and stocking headaches. As shoppers remove items, "Mylar" rolls back.

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*"Mylar" is Du Pont's registered trademark for its brand of polyester film.

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letters to the editor

might prove to be more of an incentive for new subscribers.

Incidentally, I have been familiar with the technical publications, especially those in the metals field, for about six years and I can honestly say that MATERIALS IN DESIGN ENGINEERING is my favorite for obtaining information about all materials.

I find the manuals to be most interesting. As a small criticism, I'd like to see a more extensive reference list with the manuals.

S. R. KEGLEY
Metallurgy Dept.
Goodyear Atomic Corp.
Portsmouth, Ohio

To the Editor:

Please accept my compliments on the outstanding subjects you have selected for your manuals during the past year. The one on materials testing ("New Directions in Materials Testing," M/DE, June '61, pp 117-148) was especially outstanding . . .

VERNON A. STURM
Retired Professional Engineer
Seattle, Wash.

Reprints of many M/DE manuals and special reports are available for a small fee; also, subscribers to M/DE may take advantage of a special service: you can receive reprints of a year's supply of manuals and/or special reports as they are published for only $4.50 (see 166). So far there has not been sufficient demand for binding and indexing manuals to justify the cost.

More on probability paper

To the Editor:

Although I am not a statistician, I have always been interested in and have made use of statistical methods. Here is a little more information on the subject (probability paper: M/DE, Nov '60, p 138; Feb '61, p 32; and Apr '61, p 29).

The question of plotting positions is discussed by E. J. Gumbel in *Statistical Theory of Extreme Values and Some Practical Applications*, National Bureau of Standards Applied Mathematics Series, No. 33, U. S. Government Printing Office, Washington, D. C., 1954.

Gumbel shows that the proper plotting positions are $1/(n+1)$, $2/(n+1)$ ...... $n/(n+1)$. The use of other subterfuges involves the loss of data, unwarranted assumptions, or complicated calculations.

H. S. ENDICOTT
Electrical & Electronic
Materials Engineering
General Electric Co.
Schenectady, N. Y.

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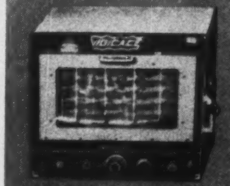

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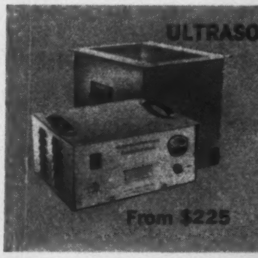

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For more information, turn to Reader Service card, circle No. 397

Painting in background: "The Piping Shepherd," by Sir Joshua Reynolds, P. R. A. (1723–1792)

New cost savings for users of dielectric materials

. . . a progress report on the MYCALEX METHOD
from Jerome Taishoff, President, Mycalex Corporation of America

"I don't have to tell you about the profit squeeze. It's a hard fact-of-life throughout our industry today. That's why we feel the *MYCALEX METHOD*—the unique molding and finishing technique we recently developed—offers so much promise.

Sample quotations point to cost savings up to 84%

"The many months spent in the developing of this new process enable us to turn out better-performing products for less: savings we, in line with our policy, will pass along directly to our customers. And those savings promise to be substantial! Note the typical parts shown in the photograph below, as well as the two mechanical diagrams. As you can see, this new production technique reveals cost reductions of 78% and 84%, respectively, when compared to previous cost quotations." Just as important, the savings are in *addition to* the high reliability SUPRAMICA® ceramoplastics and MYCALEX® glass-bonded micas are noted for.

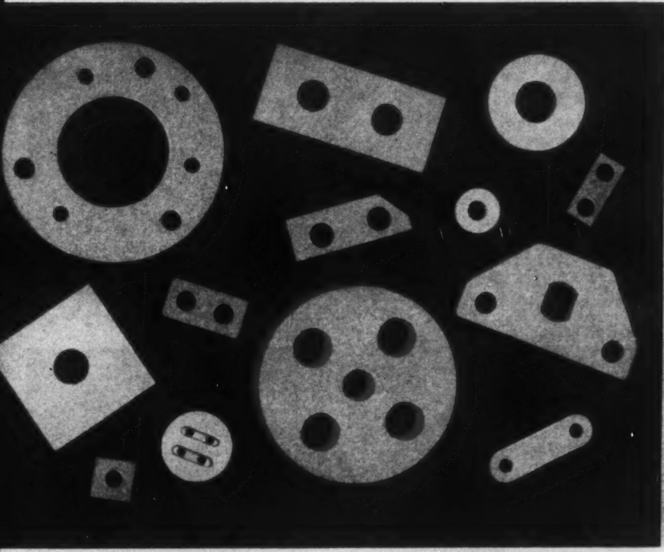
Savings plus quality with the MYCALEX METHOD

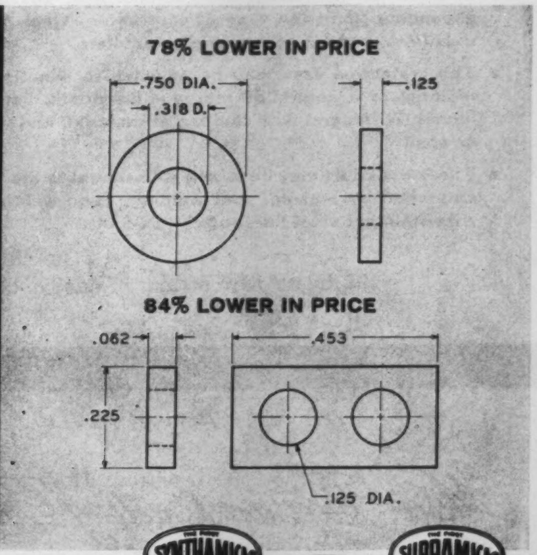
Though these intricate parts now cost much less to make—they offer the temperature endurance, total dimensional stability, high dielectric strength and low loss that SUPRAMICA and MYCALEX formulations have been delivering for years.

Choose from any of these famous materials

SUPRAMICA 620 "BB", 560 and 555 ceramoplastics and MYCALEX 410 glass-bonded mica. *Maximum Temperature Endurance* (unstressed): 1200, 930, 650 and 650°F; *Loss Factor* (10^6 cycles/sec.): 0.020, 0.010, 0.013, 0.010; *Compressive Strength* (psi): 30,000, 25,000, 40,000 and 40,000, respectively.

So for electronic insulation materials with the high-performance properties you must have—at a profit-protecting price — look into the new *MYCALEX METHOD*. Send your blueprints and drawings for specific quotations and information.





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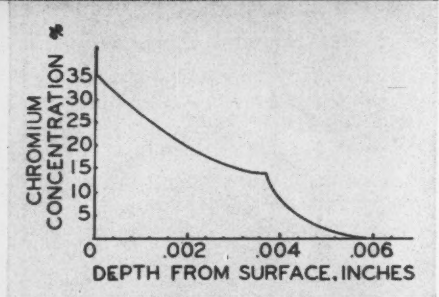
NOW! PROTECTIVE COATINGS FOR CORROSION RESISTANCE

by vapor diffusion at MISCO

The Vapor Diffusion of chromium into low-carbon steels, such as AISI 1010 to 1025, results in the formation of a highly corrosion-resistant protective alloy case which has a composition gradient similar to the 400 series of stainless steels. The chromium concentration on the surface is approximately fifty percent.

- **The protective alloy case exhibits excellent corrosion resistance to a variety of media such as tap water, weathering environment, steam, 3.% aqueous salt solution, nitric acid, fruit juices, milk products, soap solutions, and petroleum products.**
- **Usually, the protective alloy surface possesses a matte, silky grey appearance. However, by a modification of the processing parameters, a lustrous silver-colored surface may be achieved.**
- **The exact properties of the protective alloy case, such as the degree of corrosion resistance, surface hardness, and case ductility, are dependent upon the type of low-carbon steel, its cross-sectional thickness, and the processing parameters.**
- **The protective case may be adjusted to penetrate into the parent material to a controlled reproducible depth, usually 0.002 to 0.004 inches, is integral with the parent material, and will not chip, peel, or spall.**
- **These materials may be joined subsequent to the Vapor Diffusion of chromium by brazing, spot welding, seam welding, or arc welding with stainless steel filler rod.**

Our staff can assist you in the solution of your protective coating problems.



Typical curve for vapor diffusion of chromium into low-carbon steel

Bolt with vapor diffused chromium coating

Misco Precision Casting Company

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Chemlok 607 Adhesive offers unmatched advantages for bonding **uncured** specialty elastomers:

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Greater Economy — You need only **one** thin coat of Chemlok 607 and you can apply it with standard methods. It dries quickly and is less susceptible to humidity and processing variations. This gives you faster production, more uniform results, less scrap.

It will pay you to investigate Chemlok 607 Adhesive. Write for complete technical details and evaluation samples.

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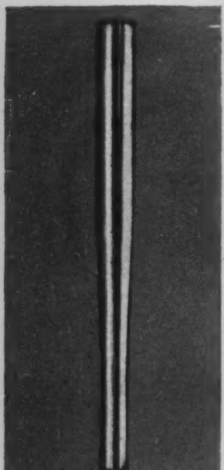
How METALOGICS* cools off the high-cost hot seat!

The following case histories are typical of how Ryerson Metalogics helps hundreds of companies save money, improve products, and cut production waste.

Metalogics-trained Ryerson specialists help you value-analyze cost-soaring production problems—and they back up their suggestions with unbiased recommendations on exactly the right steel, aluminum or plastic to do each job best for less.

Little wonder, then, that more and more companies across the country find the high-cost hot seat a little cooler after inviting a Ryerson man to value-analyze specific problems, and come up with recommendations. Give him a call—perhaps he can help answer some of your high-cost questions.

***METALOGICS**—the Ryerson science of giving optimum value for every purchasing dollar.



PRODUCTION COSTS REDUCED 40%

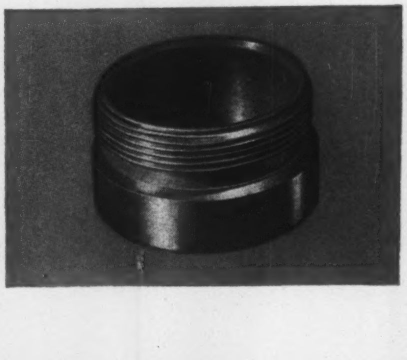
Company was making chrome-plated table legs as a 3-piece weldment and having problems in holding concentricity and making proper preparation for the mirror finish. In addition, production costs were high.

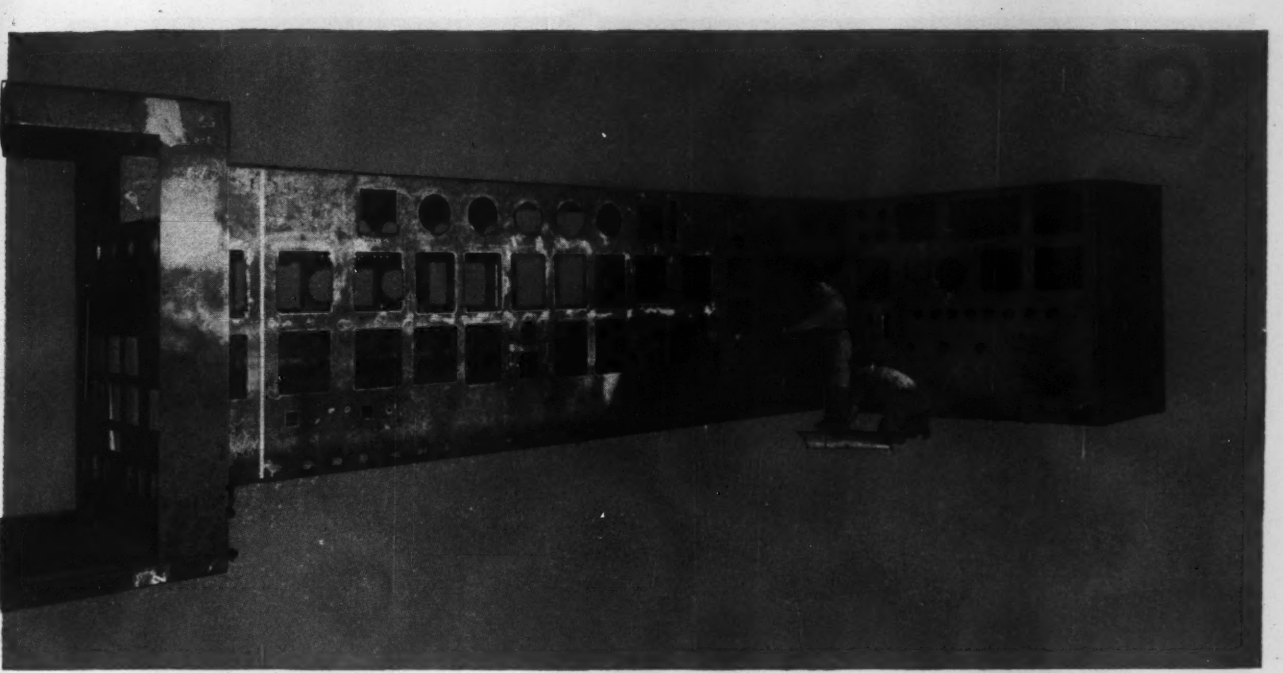
Ryerson recommended this Metalogical solution: make the legs from *one* piece of 3″ O.D. soft-annealed, cold rolled, electric-welded tubing—half the length tapered to 2″ O.D., holding concentricity to 1/32″. Results: surface was just right for chrome plating, and production cost reduced.

THREAD GALLING ELIMINATED

Manufacturer made this special coupling of aluminum to gain the advantages of light weight, corrosion resistance and easy machining. But a problem developed due to galling of threads.

Following the recommendation of a Ryerson Metalogics specialist, the company hard-coated the parts by special low-temperature anodizing which produced a surface hardness of Rockwell 70 C. Galling was eliminated, and corrosion resistance increased. One more example of top technical help from Ryerson.

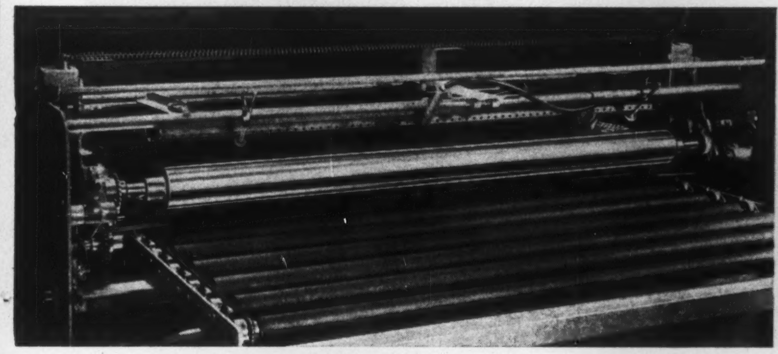




150 OPENINGS BURNED IN HUGE CONTROL PANEL ASSEMBLY

Expert Ryerson flame-cutters burned more than 150 openings in the steel plates that make up this huge control panel assembly.

Each opening had to be located and cut with extreme accuracy to permit proper installation of the complex instrument system. Distortion had to be carefully controlled and a high degree of flatness maintained so that the plates would have a good appearance when painted. All such requirements were readily met by Metalogically-oriented Ryerson service—reducing production cost substantially.



One end of close-tolerance roll. Note 3-step machining of bar.

SWITCH TO LEDLOY® STOPS TEARING...CUTS REJECTS

In making this roller coater—Gasway Corp., Chicago—was having trouble machining C-1018 bar stock to produce a close-tolerance roll. Three-step machining was required at both ends of the bar, and tearing was frequent with up to five stops per cut to regrind the tool.

After studying the problem carefully, their Ryerson specialist recommended a change to Ledloy 300. Results from this fast-machining leaded steel: higher production; longer tool life; rejects cut to a minimum.

Other steels for this coater, including angles, expanded metal, and cut-to-size side plates, are also supplied by Ryerson.

As P. A. Bill Vastine puts it, "Time and time again Metalogics takes me off the spot. It gives me technical help, plus convenient, dependable, single-source service on all my requirements."

RYERSON METALOGICS

JOSEPH T. RYERSON & SON, INC., MEMBER OF THE INLAND STEEL FAMILY

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MOLDER: *Santay Corporation, Chicago, Ill.*

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Compact, colorful and cordless, this all-transistor radio by RCA Victor is housed in a famous Impac* case that gives rugged service; won't chip, crack or break in normal use. To achieve this dramatic durability, RCA Victor engineers specified cases molded of CYCOLAC brand ABS polymers for their complete line of transistor models. Light and smooth, this most versatile of all rigid plastics defies staining from chemicals and acids and retains its molded-in color for the lifetime of the radio. Easily formed into any intricate shape, CYCOLAC brand plastic lends beauty, protection and saleability to any product . . . radios, television, telephones. See why CYCOLAC is better in more ways than any other plastic. Write Dept. L-9.

MARBON CHEMICAL DIVISION **BORG-WARNER**
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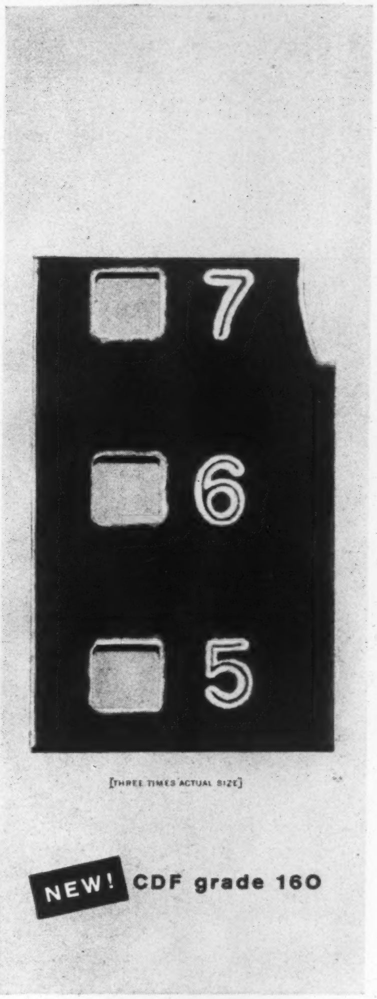

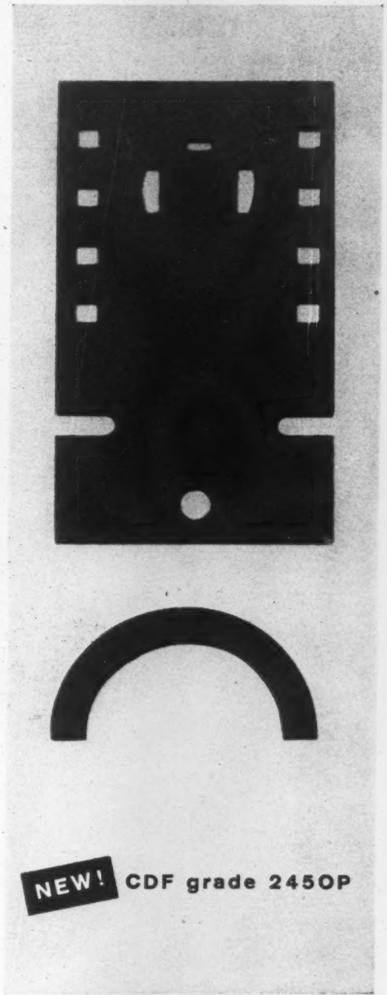

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three outstanding new laminates!

High legibility letters, numbers or symbols can be stamped on this new warm punch, paper phenolic grade in the same die used for blanking and piercing! No separate operation is necessary . . . no registration problems. Markings are permanent and in sharp contrast. Ideal for capacitor caps, terminal boards, panels, spacers, coil ends, socket bases. Meets NEMA X and XP requirements.

Economical paper phenolic grade 2450P can be punched warm and has improved mechanical strength and lower moisture absorption properties. It is designed especially for mechanical and low voltage electrical insulation applications such as connector blocks, coil and bobbin ends, washers, plug and socket bases. Meets NEMA X and XP requirements.

Excellent wet electrical and other improved properties make this new copper-clad glass fabric Teflon* laminate ideal for radar insulation, missile antennas, critical computer applications. Circuits based on this grade will show minimum drift under varying temperature and humidity. Also available without copper for such uses as high frequency insulation in wave guides.

These are the newest materials of CDF research and engineering, developed to give you outstanding performance at minimum cost. Your inquiry is welcomed.

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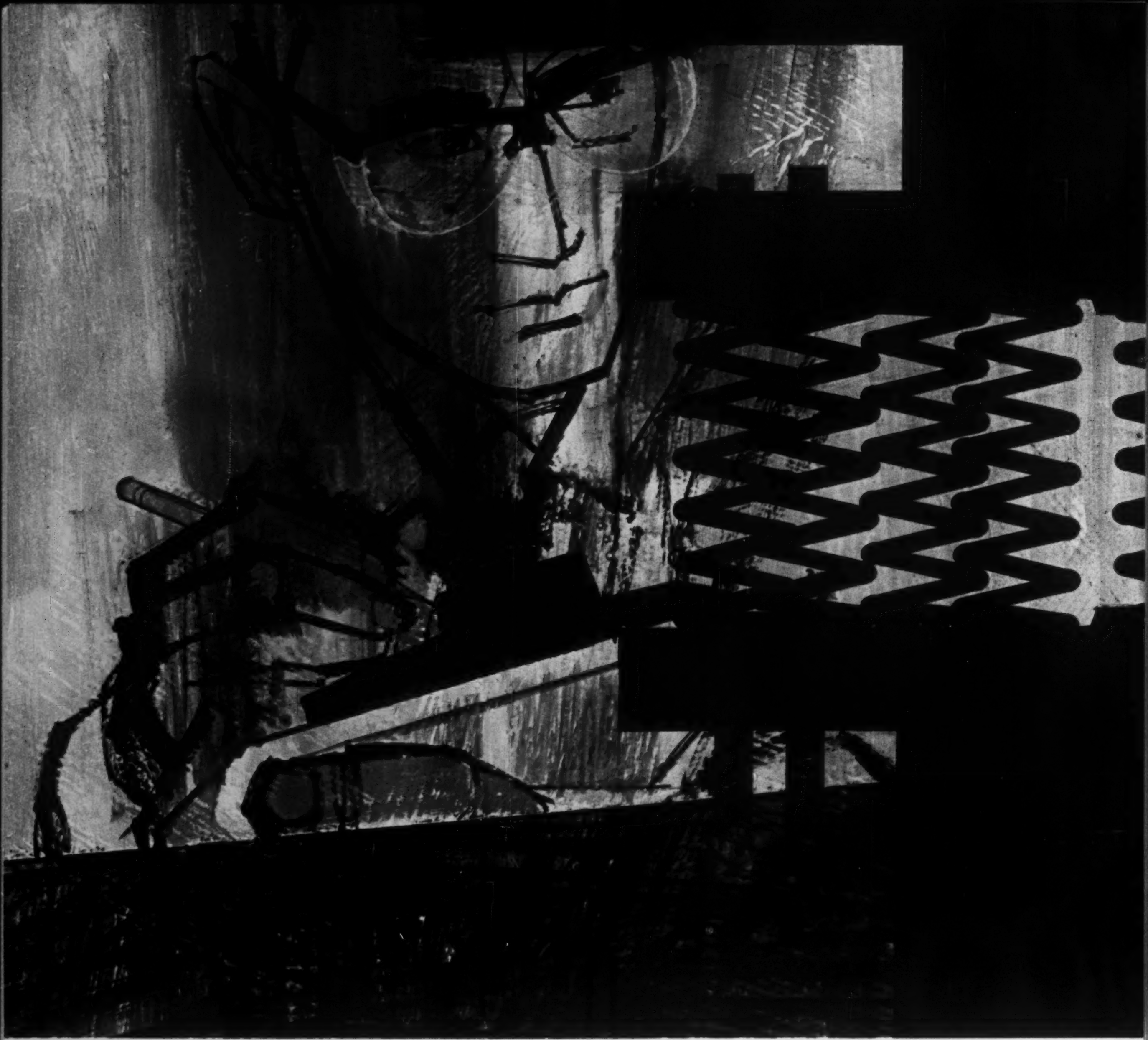


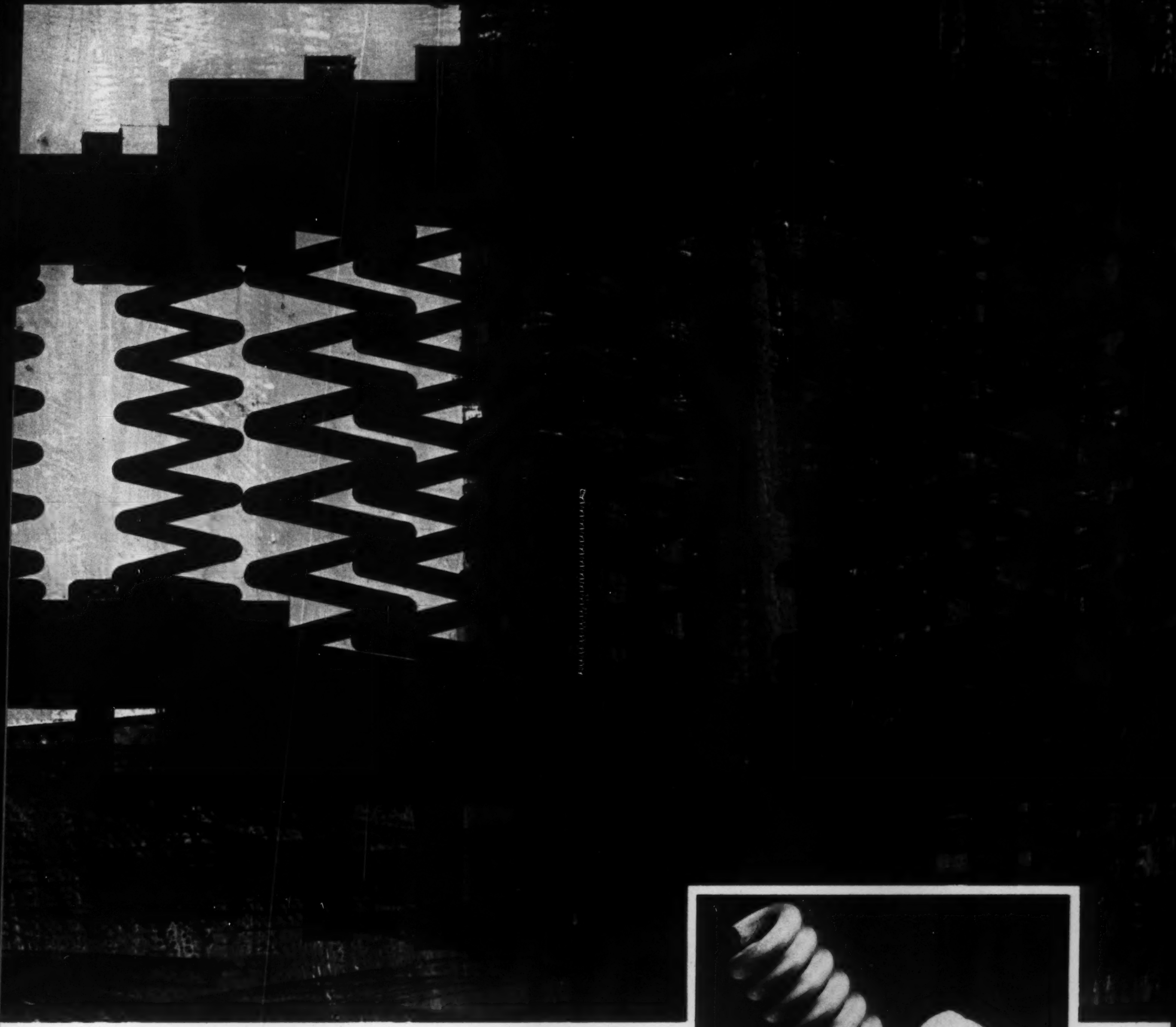
New N-S stainless wire tests 100,000 psi

From National-Standard research and development comes NS-355—a stainless steel, corrosion resistant spring wire having much greater elasticity than conventional stainless steel wire.

NS-355 is a semi-austenitic alloy, originally developed for use in heavy wire sections fabricated from bar, billet or plate stock—applications requiring corrosion resistance, strength, durability and hardness. National-Standard searched for a way to apply these outstanding advantages to highly stressed spring wire applications.

After comprehensive research in processing methods, National-Standard metallurgists developed the capability to draw NS-355 alloy into exceptionally high-tensile spring wire. Spring production tests were made on .125 and .075 inch diameter wire samples with a tensile strength over 100,000 psi higher than music spring wire, proving that NS-355 wire could be satisfactorily run on automatic coiling machines with excellent formability.

Further evaluation tests were conducted in the Spring Laboratory of Bendix Corporation, South Bend, Indiana. Here, engineers ran life cycle tests on NS-355 stainless steel springs and determined spring modulus values. On a mechanical cycling unit—eight springs to a fixture—NS-355 springs

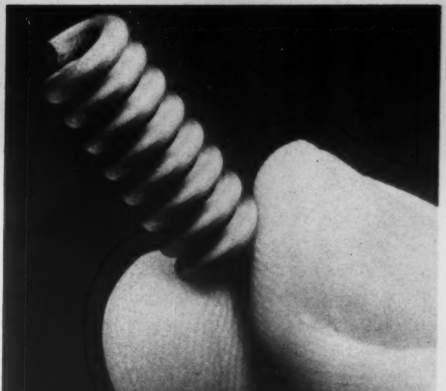


above music wire

were subjected to 600 compression cycles per minute—a total of 10-million cycles under stresses from 20,000 to 150,000 pounds.

The development of NS-355 stainless steel spring wire creates an entirely new solution to highly stressed, corrosion resistant spring requirements for jet engines, food and beverage equipment, chemical machinery and a growing number of other special wire applications.

For more information about new NS-355 stainless steel spring wire, or help in developing high quality wire to meet your special or unique applications, write National-Standard Company, Niles, Mich.



National-Standard NS-355 stainless steel springs with an index as low as 3 can be formed on automatic coiling machines without breakage.

NS NATIONAL-STANDARD COMPANY

Manufacturer of Specialty Wire & Metal Products

NATIONAL-STANDARD COMPANY

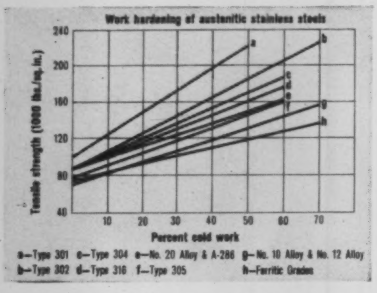
Niles, Michigan

61-W03

Design engineers demand versatility ...they get it with Stainless Steel

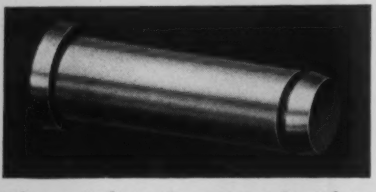
Design Engineers constantly search for materials that will serve in a wide range of applications. Here's why Carpenter Stainless Steels offer the versatility required to produce new products and improve present designs.

Cold heading applications



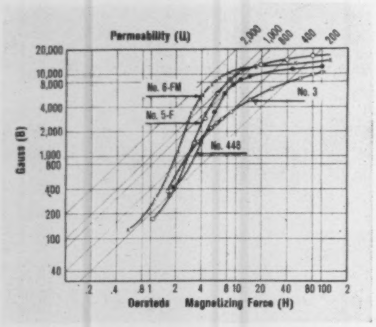
The relative cold headability of austenitic stainless and heat resisting steels is determined by their respective work hardening rates. Alloys showing the least amount of increase in hardening per given degree of cold work need less work to form them. They thus cause less tool wear. Curves for the austenitic grades in the above chart show that Type 305 stainless, a grade often used for cold headed parts, has a much lower work hardening rate than Types 304 and 316. It also indicates that Stainless No. 10 and No. 12, special stainless steels produced by Carpenter, have even lower work hardening rates than Type 305, only slightly higher than rates for the ferritic grades such as Type 430.

Production cost cut 50%



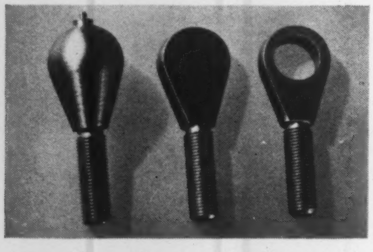
The switch to Carpenter Stainless No. 8 (Type 303) for these dishwasher hinge pivot pins increased production, improved quality and provided a cost saving of 50% per part. Tool regrinding was substantially reduced, size tolerances were accurately held and final grinding operations were completely eliminated. Along with these benefits, this customer received excellent corrosion resistance and brilliant finishes . . . two vital requirements for the successful production of this part.

Magnetic core applications



Four Carpenter Stainless Alloys are available for magnetic core applications that must operate for long periods in highly corrosive media. All four are produced to special quality standards that assure consistent uniformity in magnetic behavior. This magnetic behavior of stainless steels varies with their hardness. For consistency and best magnetic properties, the alloys should be in the fully annealed condition after all machining operations. The chart above shows the magnetization-permeability characteristics of Carpenter No. 3, No. 5-F, No. 6-FM, and No. 446 as annealed.

One change ... five benefits



Original specifications for this missile part called for heat treated alloy steel with a tensile strength of 125,000 to 145,000 psi. With the AISI 4130 steel selected for this part, the required finish could not be obtained consistently on either the threading, milling or reaming operations. Another major problem was the 25% reject rate, caused by cadmium build-up on feathered edges of the threads after plating. A request for a specification change resulted in the switch to Carpenter No. 5 (Type 416) and here's what happened! Production increased 55% . . . rejects dropped from 25% to 0 . . . cadmium coating was no longer required . . . grinding was eliminated . . . delivery requirements were easier to meet.

working data
Carpenter

New 180-page working data book on Carpenter Stainless and Heat-Resisting Steels. Includes descriptions of all grades, information on selection, fabrication tips, corrosion tables and application data. Ask your Carpenter Representative, or write for a copy.

Are you getting all these performance characteristics in the materials you specify?

- ☐ *brilliant finish*
- ☐ *maximum strength*
- ☐ *corrosion resistance*
- ☐ *uniformity*
- ☐ *hardness*
- ☐ *versatility*
- ☐ *good machinability*
- ☐ *ease of fabrication*
- ☐ *exacting tolerances*
- ☐ *long service life*
- ☐ *customer satisfaction*

Carpenter Stainless gives you *all* these . . . and more!

Carpenter steel

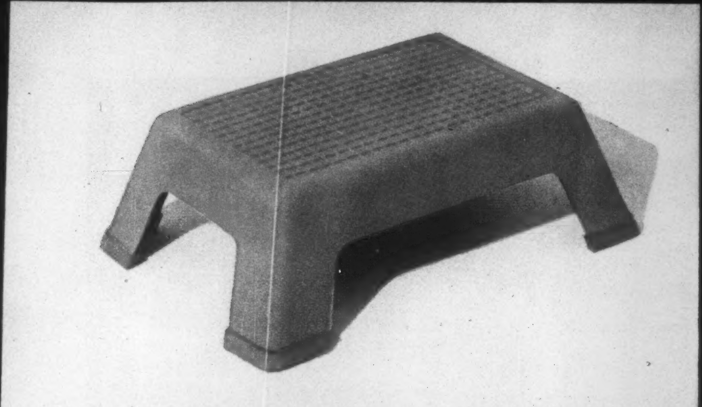
you can do it ***consistently*** better with Carpenter Stainless Steels for specialists

Stainless Steel

The Carpenter Steel Company, Main Office and Mills, Reading, Pa.
Export Dept., Port Washington, N.Y.—"CARSTEELCO"
Alloy Tube Division, Union, N.J.
Webb Wire Division, North Brunswick, N.J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.

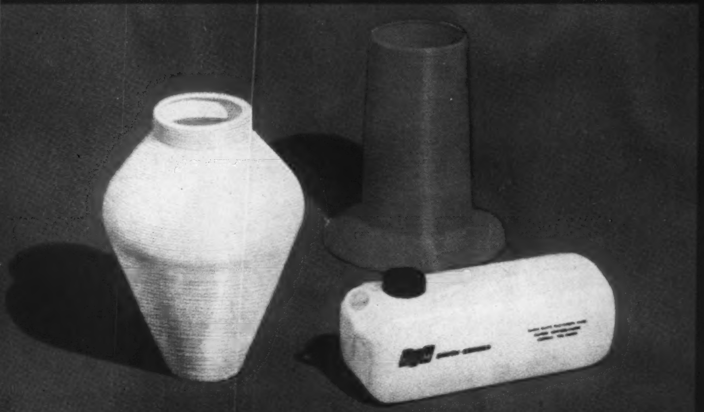
◄ For more information, circle No. 458

▲ For more information, turn to Reader Service card, circle No. 337



INJECTION MOLDED—This hospital footstool is typical of the products and parts made of MARLEX for hardware, auto, appliance, furniture, housewares, toy, and other industries. (Footstool, Consolidated Molded Products, Scranton, Pa.)

THERMOFORMED—Many items are economically formed of MARLEX sheet: tote boxes, trays, automotive and industrial components, food packages . . . even light, sturdy boats. (7' SPORTYAK®, Woodall Industries, Inc., Detroit 34, Mich.)



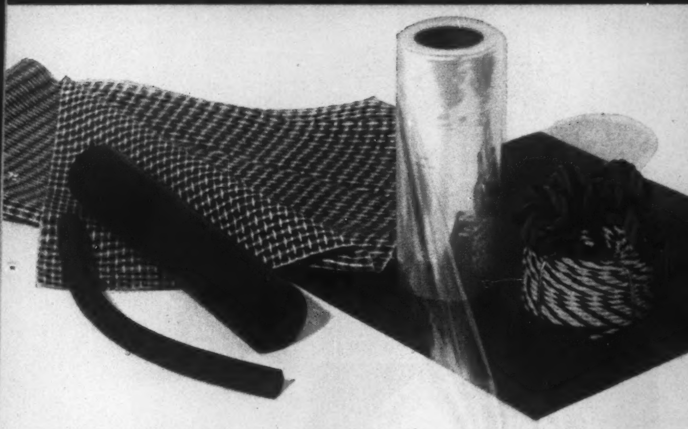
BLOW MOLDED—MARLEX blow molding resins provide superior lampshades, containers . . . a variety of large and small components. (Container, HYSPEC by Hydrocarbon, Keyport, N. J.) (Lampshade, Haveg Industries, Bound Brook, N. J.)

By every method . . .

MARLEX* quality assures success

MARLEX high density polyethylenes, ethylene copolymers and tailored resins afford you versatility and outstanding product quality at moderate cost. They enable you to produce items which are durable, tough, light, corrosion proof and rot proof . . . and produce them at low cost. Products made of MARLEX withstand temperature extremes (–180°F to 250°F) . . . acids, alkalies, oils and greases. Get complete information about MARLEX today! Your inquiry will get prompt attention and an early response.

*MARLEX is a trademark for Phillips family of olefin polymers.



EXTRUDED—Large and small pipe for many uses, electrical conduit, filament and yarn for rope and fabric, sheet or clear film . . . are extruded products made better of MARLEX.

Garden
PEAT
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OVER 95 PERCENT ORG

BLOWN FILM—Thin, yet tough, strong and light, MARLEX is used for bulk bags, construction barriers, agricultural and industrial films. (Bag, Crystal-X Corp., Lenni Mills, Pa.)

For more information, see your plastic fabricator, or contact us.

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Bartlesville, Oklahoma
A subsidiary of Phillips Petroleum Company

PHILLIPS 66
MARLEX

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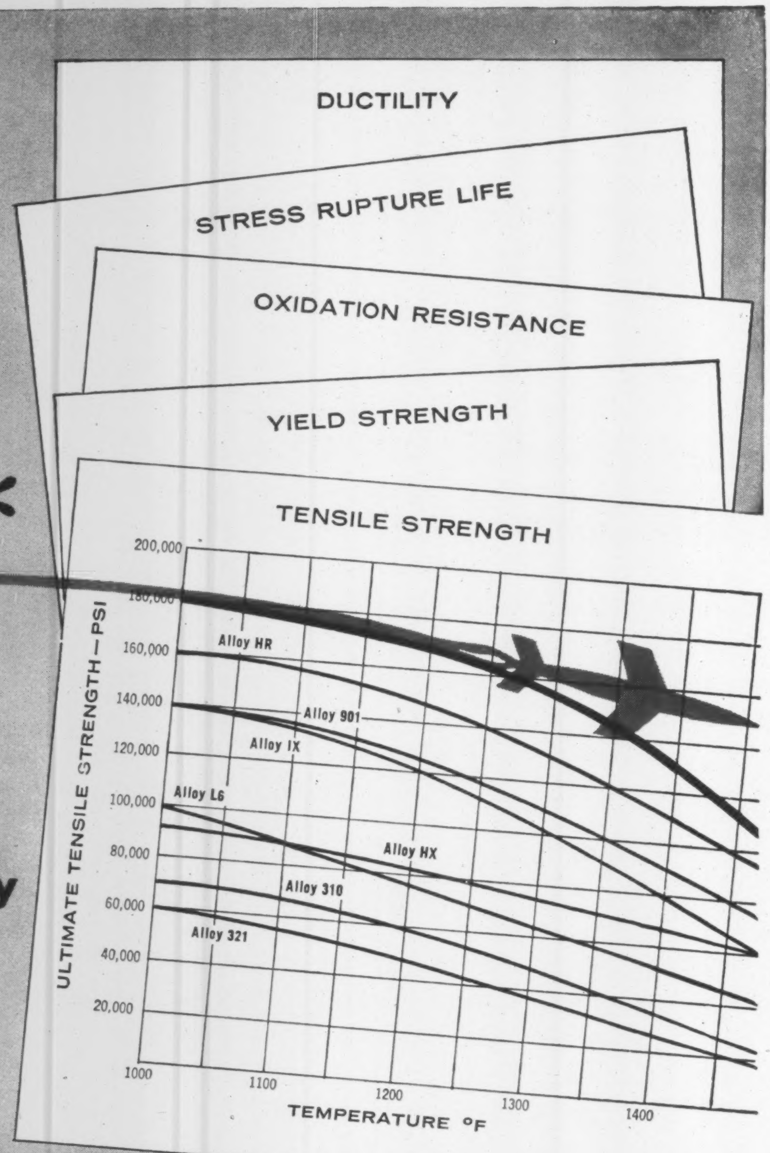
HIGH

on every chart:

RENÉ 41*

most dependable alloy in use today in the 1200°- 1800°F range



In *all* ways, René 41 is a remarkable alloy. No other high-temperature alloy used in production today equals its tensile strength. In other properties, too, René 41 is far ahead of the field.

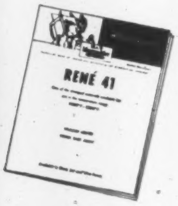
Also important, this nickel-base, vacuum-melted alloy is easy to work with. It's readily formable by drawing, bending, spinning — welds to similar or dissimilar materials.

Cannon-Muskegon offers René 41 in standard 36″x 96″ sheets .015″ to .125″ thick, in smaller sizes down to .010″, in bar stock up to 3″ in diameter . . . foil down to .001 in thickness . . . and fine wire only .0015 in diameter.

For complete details, write for Technical bulletin No. 86.

*TM of General Electric Co.

ULTRAMET
VACUUM ALLOYS



RENÉ 41

CANNON-MUSKEGON CORPORATION
2873 Lincoln Avenue • Muskegon, Michigan
METALLURGICAL SPECIALISTS

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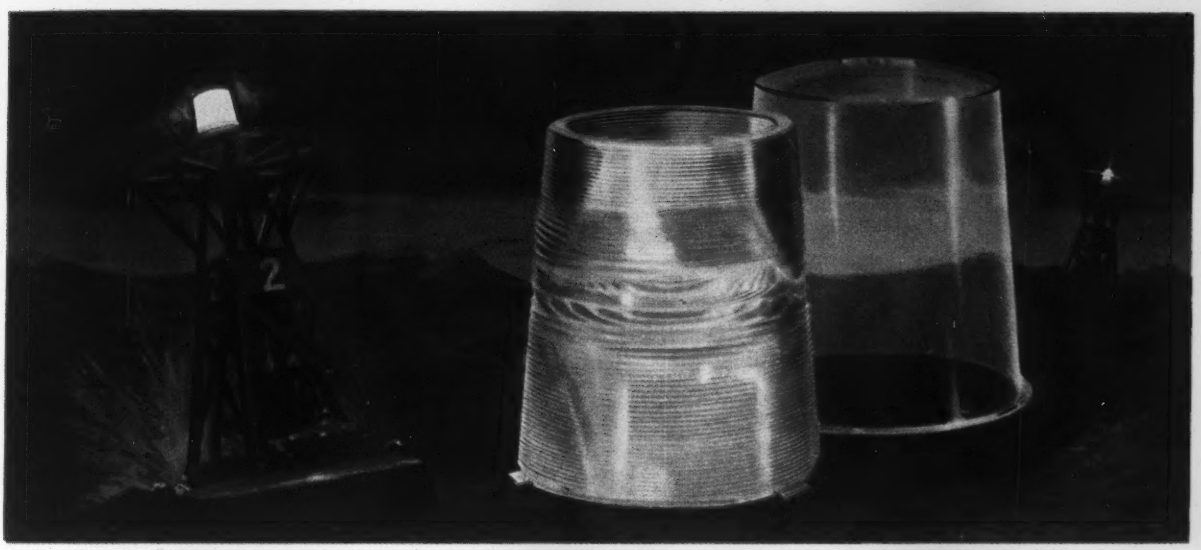

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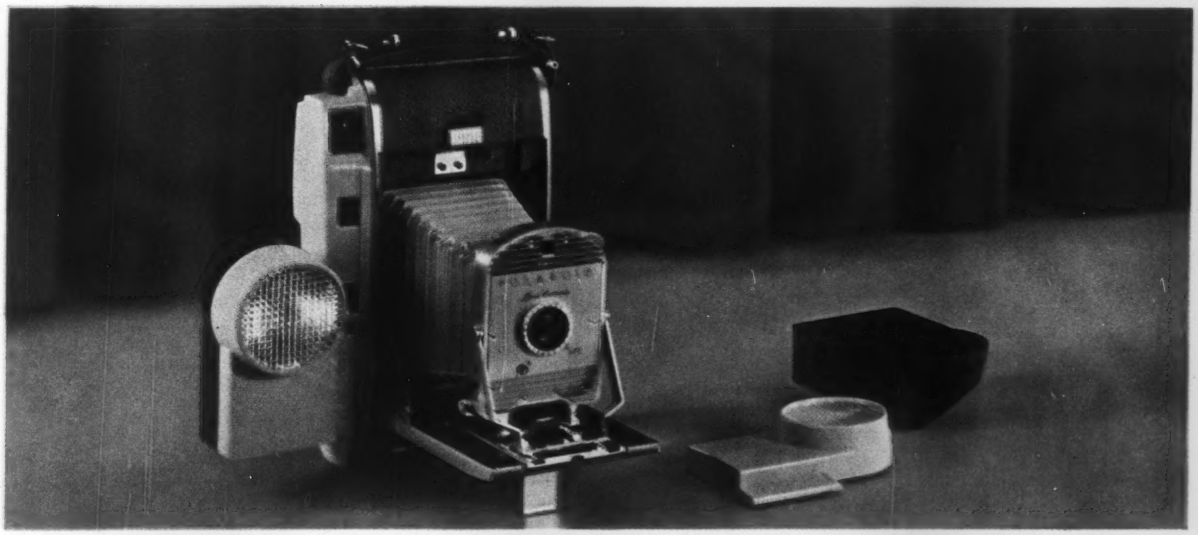
Plexiglas...Implex



Flashing lights at sea shine brightly through large lenses and covers molded of PLEXIGLAS® acrylic plastic. The PLEXIGLAS parts are used in navigation lights for the U. S. Coast Guard, at a fraction of the cost and weight of cut glass lenses. Precision molding of the lens pattern gives the PLEXIGLAS lens maximum efficiency in light control, and the material resists weather, breakage and salt water.

Winking lights at home are revolutionizing indoor photography by making indoor pictures without flashbulbs possible, with the new wink-light attachment shown above. Tough IMPLEX®, the high impact acrylic, gives handsome appearance and rugged durability to the housing. PLEXIGLAS is used for the lens.

We will be glad to help *you* use these Rohm & Haas acrylic molding materials—to your advantage.

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PHILADELPHIA 5, PA.

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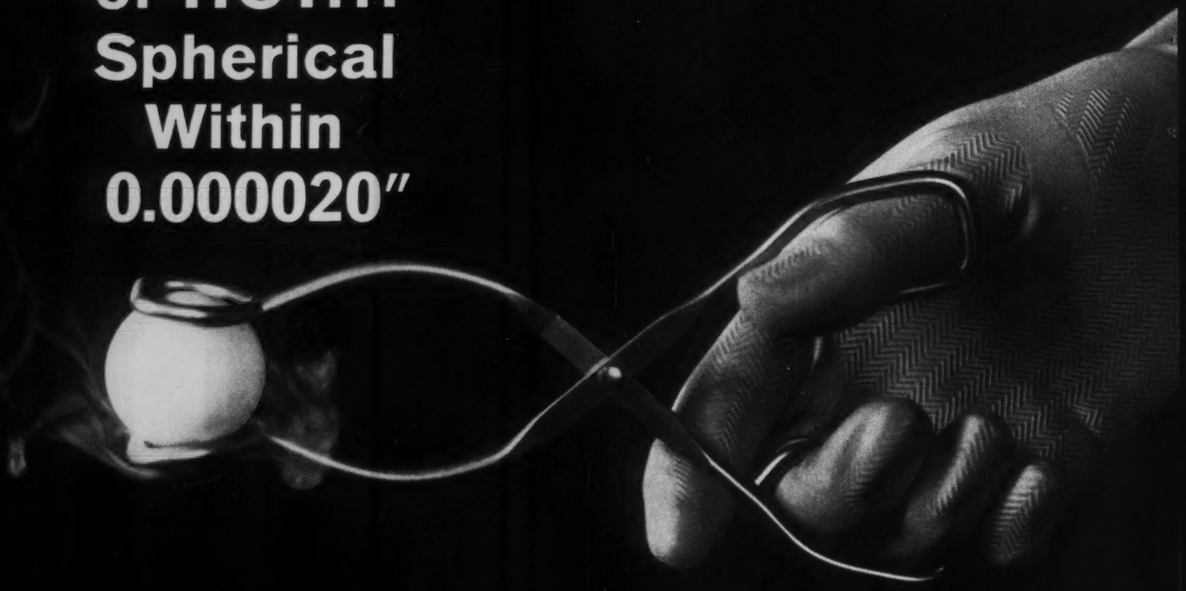
COLD or HOT... Spherical Within 0.000020"



Tolerances up to 0.000020" can be obtained on Coors high alumina spherically ground balls. Tolerances remain constant at cryogenic, room or elevated temperatures, because the material is dimensionally stable over a wide temperature range. Applications for Coors spherically ground balls include bearings, gauges and check valves. Coors high alumina ceramics are hard (Rockwell 45N 75-81) and extremely wear resistant—over 240,000 psi to over 350,000 psi compressive strength—completely homogeneous—chemically inert—non-magnetic—less than half the weight of steel, less than one-fourth the weight of tungsten carbide. Spherically ground balls, spherical within 0.0001", are kept in stock covering a wide range of sizes. Write for Data Sheet No. 5004. Regional Sales Managers: WEST COAST, *William S. Smith, Jr., EM 6-8129, Redwood City, Calif.;* MIDWEST, *John E. Marozeck, FR 2-7100, Chicago, Ill.;* CENTRAL, *Donald Dobbins, GL 4-9638, Canton, Ohio;* EAST COAST, *John J. McManus, MA 7-3996, Manhasset, N. Y.;* NEW ENGLAND, *Warren G. McDonald, FR 4-0663, Schenectady, N. Y.;* SOUTHWEST, *Kenneth R. Lundy, DA 7-5716, Dallas, Texas;* OIL FIELD INDUSTRY, *William H. Ramsey, UN 4-6369, Houston, Texas.*

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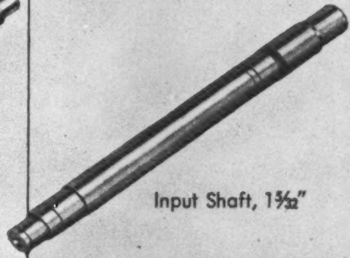
It costs less than heat treated in-the-bar alloys.

with copper

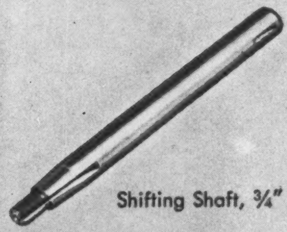
Strength Without Heat Treating

Worm Shaft, 1½"

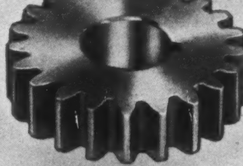


Input Shaft, 1 5/32"

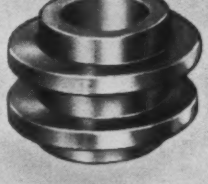
Driving Axle, 1 5/32"



Shifting Shaft, ¾"



Reverse Pinion, 3"



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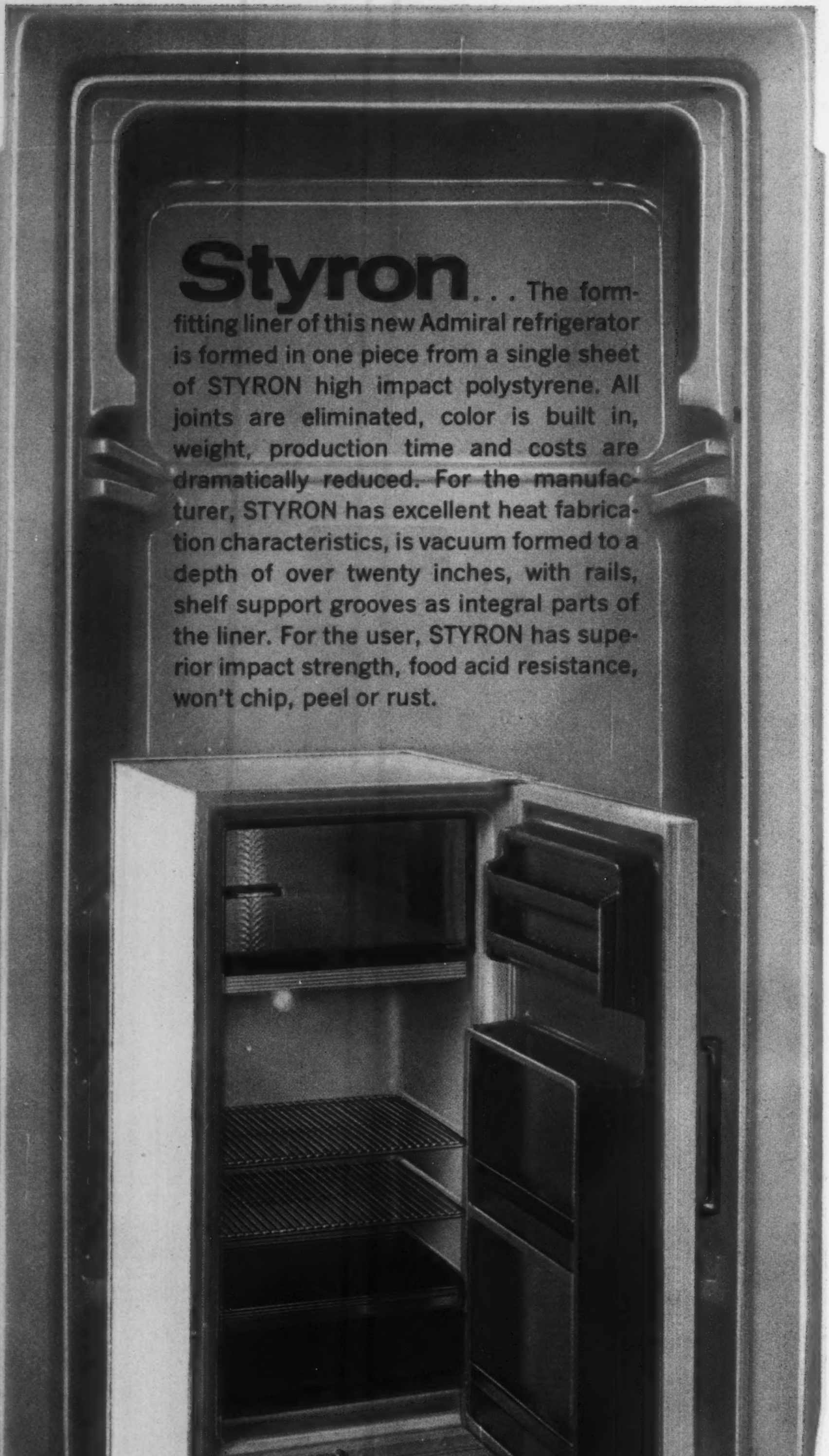


Styron. . . The form-fitting liner of this new Admiral refrigerator is formed in one piece from a single sheet of STYRON high impact polystyrene. All joints are eliminated, color is built in, weight, production time and costs are dramatically reduced. For the manufacturer, STYRON has excellent heat fabrication characteristics, is vacuum formed to a depth of over twenty inches, with rails, shelf support grooves as integral parts of the liner. For the user, STYRON has superior impact strength, food acid resistance, won't chip, peel or rust.

Styron . . . high impact Dow polystyrene

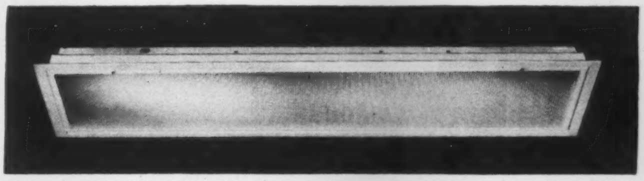
streamlines production in deep-draw, vacuum-forming operation for Admiral

The Styron® high impact polystyrene liner in Admiral Sales Corporation's new nine-cubic-foot apartment-size refrigerator cuts production time by 90% and up-grades quality and product appearance at the same time. This new concept in thermal forming offers designers and fabricators unlimited opportunities for deep-draw, one-piece components.

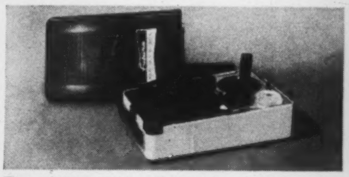
Using a new rotary vacuum-forming machine, and fifteen pounds of high-impact Styron 475B, Admiral deep-forms a one-piece refrigerator liner 46½" high x 23¾" wide x $20\frac{12}{32}$" deep *in two minutes!* Contrast the half-hour total production time and the reduction in float quantities required in this operation with the five hours' total production time and twenty-two pounds of material required to fabricate the previously used liner.

The finished design: a smooth, food acid resistant liner with built-in color that won't crack, chip, or rust . . . with no joints . . . and with more efficient insulating qualities. Formed into the liner are the crisper rail, two shelf supports, grooves, a two-position freezer drawer slide rail, and four bosses for mounting the evaporator.

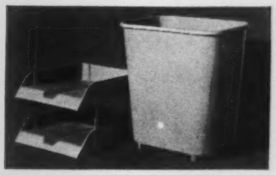
The unusual size of Admiral's one-piece vacuum-forming operation opens the door to deep-drawn designs of even larger and more complex shapes. May we add our experience to yours to help solve a design problem? Drop us a line in Midland, Attention: Plastics Sales Department 1721CD9.



Light stabilized panel, extruded of Styron Verelite®, enables this K-S-H lighting fixture to provide a low brightness controlled light.



Transistor radio-phono combination by Bell Products is enclosed in case of Styron® for good impact strength and brilliant color styling.



Wastebasket by Rubbermaid uses flexible, chip-resistant, easy-to-clean Dow medium density polyethylene. Letter tray of Styron.

THE DOW CHEMICAL COMPANY DOW **Midland, Michigan**

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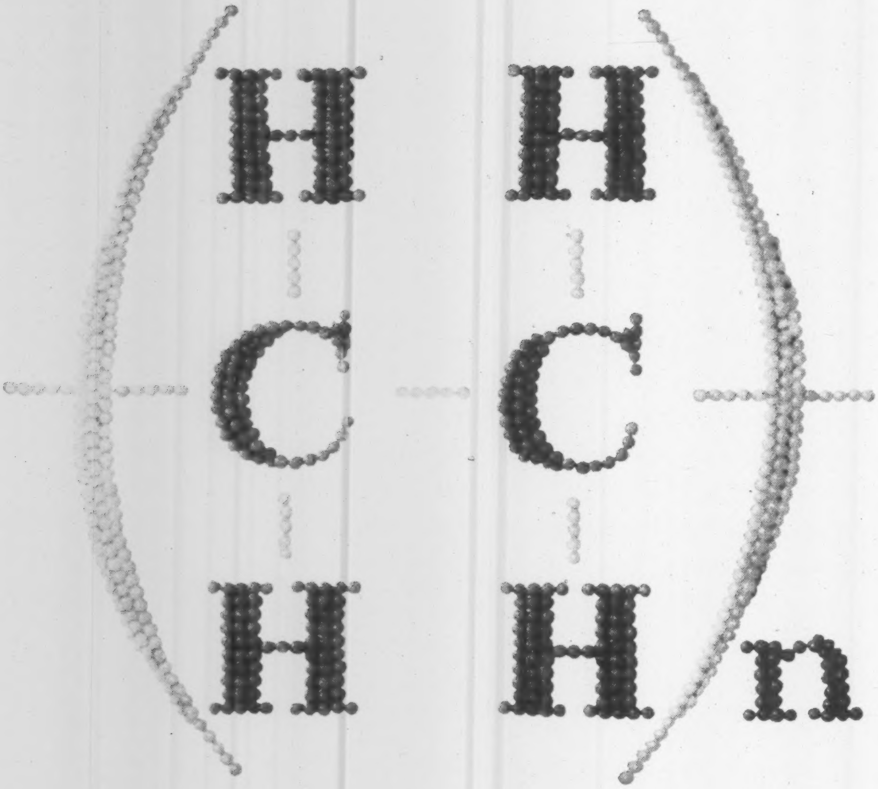

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Steel spring wire	178	610
Aluminum alloy for sand cast parts	200	623
Superconductive wire	206	628

PLASTICS & RUBBER		
Stiffer polypropylene	9	600
Large nylon shapes	15	605
Light ablation plastic	184	614
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Two synthetic latexes	194	619 & 620
Polycarbonate resin	208	629
Two nylon 6 resins	210	632

OTHER NONMETALLICS		
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Colloidal alumina strengthens materials	186	615
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19	44	69	94	119	144	169	194	219	244	269	294	319	344	369	394	419	444	469	494	519	544	569	594	619	644	669	694
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22	47	72	97	122	147	172	197	222	247	272	297	322	347	372	397	422	447	472	497	522	547	572	597	622	647	672	697
23	48	73	98	123	148	173	198	223	248	273	298	323	348	373	398	423	448	473	498	523	548	573	598	623	648	673	698
24	49	74	99	124	149	174	199	224	249	274	299	324	349	374	399	424	449	474	499	524	549	574	599	624	649	674	699
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Suppliers' New Bulletins

ABS Plastics. Marbon Chemical Div., Borg-Warner Corp., illus. Advantages, characteristics, properties, and other information on the use of ABS plastics for automobile interior components, including steering wheels, dash panels, seat shells, trunk liners, etc. **1**

Beryllium Copper Strip. Brush Beryllium Co., 4 pp. Composition, specifications, physical and mechanical properties, heat treatment, forming and joining data, plating and coloring information, available sizes, and a chart showing tensile strength versus formability of beryllium copper strip. **2**

Spun End Tube. Wolverine Tube Div., Calumet & Hecla, Inc., 32 pp, illus. Information on a new method of forming tube which combines reducing, necking, closing, fabricating, etc. Includes information on what the process is, what it will do, what materials can be used, tube sizes, and a series of case histories which illustrate advantages of new method over old method. **3**

Resistance of Steel to Hydrogen. Climax Div. of American Metal Climax, Inc. Summarizes the present state of knowledge and suggests future potentialities. Covers a wide variety of engineering steels and discusses such things as physical-chemical reactions; heat treatment and welding; tensile, toughness and long time stress-rupture characteristics; structural changes; etc. **4**

Plastics Data Sheets. Conneaut Rubber & Plastics Co. Series of data sheets cover nine of the most widely used thermoplastic materials, including vinyls, polyethylene, styrenes, butyrate, nylon, chlorinated polyether, and ABS polymer. Includes data on typical uses; physical, electrical and chemical characteristics; and sizes, forms, and available colors. **5**

Industrial Ceramics. Du-Co Ceramics Co., 16 pp, illus. Information on the services and facilities available for the production of steatite, forsterite, cordierite, zircon porcelain, mullite, wollastonite, alumina, etc. Includes information on production and fabrication of typical extruded and pressed parts, and a chart giving physical, mechanical, chemical and electrical properties of ceramic. **6**

Synthetic Rubber. E. I. du Pont de Nemours & Co., Inc., Elastomer Chemicals Dept., 8 pp, illus., No. 100. Series of case histories illustrate advantages, characteristics, and uses of neoprene, neoprene adhesives, Hypalon, and urethane rubbers. **7**

Polypropylene. Eastman Chemical Products, Inc., Plastics Div., 7 pp, illus., No. 9. General information on advantages and characteristics of polypropylene, including charts on chemical resistance, physical and mechanical properties, and suggested formulas for various types of processing. **8**

Vinyl-Metal Laminates. Enamel Products & Plating Co., 4 pp, illus. Information on advantages, characteristics, sizes, and typical applications of vinyl-metal laminates and vinyl-coated steel and aluminum coils. **9**

Electrical Contacts. Fansteel Metallurgical Corp., 4 pp, illus., Vol. 1, No. 1. Case histories illustrate advantages, characteristics and typical uses of electrical contacts and contact assemblies made of tungsten, precious metals, and special alloys. **10**

Gasket Materials. Garlock Inc., 24 pp, illus., No. AD-190. Attempts to answer the following three important questions: What are the best available gasket materials? How do you choose the right one? What is the correct gasket design? Includes information on chemical resistance, specifications, high pressure and high temperature applications, etc., for many standard and several newer gasket materials. **11**

Polycarbonate Films. General Electric Co., Chemical & Metallurgical Div., Chemical Materials Dept., 13 pp, No. CDC-396. General information and suggested applications, mechanical properties, effects of moisture, effects of heat aging, permeability, chemical resistance, optical and electrical properties, area factor, production methods, and other information on polycarbonate films. **12**

Self-Bonding Silicone Rubber. General Electric Co., Silicone Products Dept., 4 pp, illus., No. CDS-57. Advantages, characteristics, properties, typical uses, techniques, and other information on the use of self-bonding silicone rubber compounds. **13**

Polyethylene Insulation. Goodrich-Gulf Chemicals, Inc., 6 pp, illus., No. 2. Properties, advantages, insulation resistance, and other information on the use of polyethylene for wire and cable insulation. **14**

Gray Iron Castings. Gray Iron Founders' Society. Buyers' Guide and Directory of Gray Iron Founders' Society lists 1) companies producing gray and ductile iron castings, including data on personnel, monthly production, size, and type and use of castings; 2) trade marks; and 3) a list of foundries arranged by type of product manufactured. Write directly on company letterhead to Gray Iron Founders' Society, Inc., National City-E. 6th Building, Cleveland 14, Ohio.

Properties of Cast Irons. Hamilton Foundry Inc., 6 pp, illus., No. PS-561. Chart lists significant properties and specifications of approximately 40 irons and alloys cast by this company. Includes information on heat treatments and typical cast parts. **15**

Polyurethane Foams. Durez Plastics Div., Hooker Chemical Corp., 4 pp, illus., No. D-300. Advantages, characteristics, properties, available forms, and other information on heat retardant polyurethane foams. **16**

Tooling Materials. Hysol Corp., No. T-100A. Advantages, characteristics, and typical uses of casting, laminating, and surface coat compounds. **17**

Aluminum Casting Alloy. William F. Jobbins, Inc., 8 pp, illus. Advantages, characteristics, properties, uses, availability, and other information on a new high strength shock resistant aluminum casting alloy. **18**

Silicone Fibers. Johns-Manville Sales Corp., Industrial Insulation Div., 4 pp, illus., No. IN-330A. General information, availability, properties, sizes, and other information on high temperature silicone fibers for insulation and reinforcement. **19**

Heavy Tungsten Alloy. Kennametal, Inc., 8 pp, illus., No. B-500. Information on sizes and shapes, typical applications, physical and mechanical properties, machining and joining recommendations, and other information on a heavy tungsten alloy for use in radioactive shielding, balancing, and high inertia rotation applications. **21**

Steel Bar. La Salle Steel Co., illus., series of case studies illustrate advantages, characteristics, properties, economics, and other information on the use of steel bars for various applications. **22**

Ceramic, Investment Molding. Lebanon Steel Foundry, Specialty Foundry Div., 2 pp, illus., No. 8. Information on how ceramic and investment molding are combined in a single casting to take advantage of the low tooling and pattern costs of ceramic molding and the added dimensional and tolerance control of investment molding. Includes description of process and typical parts being cast **23**

Etch Resistant Material. Meaker Co., Chemical Div., 4 pp. Advantages, characteristics, properties, and typical uses of an etch resistant material for printed circuit. **24**

Plastic Coating. Pfaudler Co., Div. of Pfaudler Permutit Inc., 4 pp, illus., No. 1007. Advantages, characteristics, uses, physical properties, corrosion resistance, method of application, and other information on a corrosion resistant chlorinated polyether coating for metals. **25**

Stainless Steels. Republic Steel Corp., 32 pp, illus., No. 1223. Compositions, available forms, available conditions, typical applications, heat treatments, fabrication data, and typical room and elevated temperature properties of 17-4 PH, A-286, 17-7PH, and PH 15-7 Mo precipitation hardenable stainless steels. **26**

Machining Aluminum. Reynolds Metals Co. Information on tools, machinability, speeds, lubricants, angles, etc., on machining aluminum. **27**

Polyvinyl Properties. Shawinigan Resins Corp., 12 pp. Advantages, characteristics, properties, and suggested uses for polyvinyl formal, polyvinyl butyral, polyvinyl alcohol and polyvinyl acetate resins, emulsions and spray-dried powders. **28**

Tantalum-Tungsten Alloy. Stauffer Metals Div., Stauffer Chemical Co., 2 pp. Composition, physical and mechanical properties, effects of rolling on hardness, effects of annealing temperature, elevated temperature tensile properties, stress - rupture data, and fabrication information on a 90 tantalum-10 tungsten alloy. **29**

Reinforced Plastics. Swedlow Inc., illus., No. 300-61. A review of current materials, fabrication techniques, and applications of reinforced plastics. Special attention is given to high temperatures. **30**

Machining Laminated Plastics. Synthane Corp., 8 pp, illus., No. S-1060. Provides general machining information and describes specific techniques, including sawing, turning and boring, threading, automatic screw machining, drilling, milling, gear cutting, punching, etc. Includes information on design, sizes and grades. **31**

Copper-Clad Laminate. Taylor Fibre Co., 2 pp, No. 51.5.15. General description, specifications, characteristics, tolerances, forms, properties, and other information on a glass-epoxy, copper-clad plastics laminate. **32**

Air Hardening Tool Steel. Timken Roller Bearing Co., Steel & Tube Div., 4 pp, illus. Advantages, characteristics, properties, heat treatment, typical uses, and other information on an air hardening tool steel. **33**

Overlay Fabrics. Union Carbide Chemicals Co., Div. of Union Carbide Corp., 8 pp, illus., No. T-2045. Properties, advantages, methods of application, recommended uses and other information on the use of acrylic fiber overlay fabrics for protection of glass-reinforced plastic laminates **34**

Prealloyed Stainless Powder. Vanadium-Alloys Steel Co., 2 pp. Composition, properties, applications, and other information on prealloyed stainless steel powders. **35**

Cutting Tool Alloy. Vascoloy-Ramet Corp., 12 pp, illus., No. 6102. Characteristics, advantages, properties, available types, uses, cutting speeds, and other information on a series of cobalt, chromium, tungsten, columbium, and carbon cutting tool alloys. **36**

Shell Mold Castings. Westinghouse Electric Corp., Materials Mfg. Dept., 8 pp, illus., No. 52-520. Advantages, characteristics, suitable materials, typical parts, design information, tolerances, surface finish, size limitations, properties of materials, and typical applications of shell mold castings. **37**

Copper-Clad Laminates. Westinghouse Electric Corp., Micarta Div., 8 pp, No. B-8215. General information on advantages and characteristics; sizes and specifications; recommended applications; fabrication; and physical, mechanical, and electrical properties of several grades of copper-clad plastics laminates. **38**

Powder Metallurgy Parts. U. S. Graphite Co., Div. of Wickes Corp., 6 pp, illus., No. 19. General information on advantages, characteristics, tolerances; design; selection factors; typical parts; and other information on powder metallurgy parts. **39**

Other Available Bulletins

Irons & Steels • Parts • Forms

Manganese Steel Products. American Manganese Steel Div., American Brake Shoe Co., 16 pp, illus., No. 2. Information on the use of manganese steel for hard facing and for construction equipment. **40**

Vinyl-Metal Laminate. American Nickeloid Co., 6 pp, illus. Specifications, uses and fabrication of vinyl-metal laminate sheets, strips and cuts. **41**

Metallurgy of Tubing. Babcock & Wilcox Co., Tubular Products Div., 36 pp, illus. Series of short articles give information on such things as high temperature applications of tubing, elevated temperature strength, machinability, nondestructive testing, stress corrosion cracking, effects of alloying elements, residual stresses, heat treatment, hardenability, mechanical properties, etc. **42**

Carbon Steel Bars. Bethlehem Steel Co., 32 pp, illus., No. 366. Information on how to select carbon steel bars. Covered are types of carbon steel; availability; effects of constituents; and descriptions of rimmed, killed, semi-killed, and capped steels. Also covered are heat treatments and fabrication properties. **43**

Steel Castings. Calumet Steel Castings Corp., 4 pp, illus. Specification chart lists compositions, tensile strength, yield point, elongation, reduction of area, and Brinell hardness of carbon, alloy, and stainless steel castings. **44**

Machining Stainless Steels. Carpenter Steel Co. Slide chart gives precise data on turning, drilling, tapping, threading, milling, and reaming stainless steels. Includes relative workability and information on such operations as blanking, deep drawing, stamping, forging, heading, roll threading, welding, etc. **45**

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Metal Powder Parts. Eaton Mfg. Co., Powdered Metals Div., 8 pp, illus., Vol. 18, No. 2. Article discusses metal powder parts in general, several methods of producing them, equipment and facilities required, heat treatment of iron powder parts, and mechanical properties of various iron powders. **47**

Rolled Steel Rings. Edgewater Steel Co., 12 pp, illus. Describes and illustrates a process by which rolled steel rings are formed from solid blocks. **48**

Ultra Thin Strip. Hamilton Watch Co., Metals & Electronics Div., 2 pp, illus. Services and facilities available for the production of ultra thin metal strip. Included is information on materials available, special alloys, and sizes and tolerances. **49**

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Metal Spinning. Phoenix Products Co., Inc., Metal Spinning Div., 4 pp, illus., No. F960. Advantages, characteristics, and typical uses of various metal spinnings. Includes information on sizes, tolerances, and alloys. **54**

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Guide to Ferrous Metallurgy. Tempil Corp., 8½ × 11-in. chart, illus. Chart presents carbon-iron diagram and shows important working zones in black and in colors; also indicates black heat range and characteristic hot-body radiant hues. Changes in grain size with temperature are schematically illustrated at left and 24 fundamental metallurgical terms are defined at right. **58**

Small Metal Parts. Torrington Co., Special Metal Parts Div., 24 pp, illus. Services and facilities of the company for producing small precision metal parts. Information also on contract swaging and swaging machines. **59**

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Copper-Base Alloys. Ampco Metal, Inc., 16 pp, illus., No. G-60. Chemical compositions, physical properties, and typical applications of a series of wear and corrosion resistant copper-base alloys. Includes a description of services and facilities available for the production of sand, centrifugal, and shell mold castings; extrusions; machined parts; and fabrications and finished products. **66**

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Tungsten, Molybdenum. General Electric Co., Lamp Metals & Components Dept., 80 pp, illus. Properties, structure, finishes, uses, availability, and prices of tungsten and molybdenum metal powders, rod, and wire. **74**

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Vanadium Catalysts. Vanadium Corp. of America, looseleaf. Bibliography of references to vanadium catalysts, for the years 1940 to 1954, covers reaction descriptions, catalyst employed in each case, and the names of the observer and source publication. **85**

Nickel Alloys. Wall Colmonoy Corp., Hard Facing Div., 1 p, No. T-1. Chart lists the corrosive media in which nickel alloys are generally resistant and discusses corrosion resistance in general terms. **86**

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Corrosion Resistant Castings. Waukesha Foundry Co., Castings Div., 18 pp, illus. Information on the services and facilities available for the production of corrosion resistant castings. Includes data on compositions, mechanical properties, and corrosion resistance. Also covers specifications and properties of special casting alloys. **87**

Nylon Screws. Weckesser Co., 3 pp, illus. Installation data for black nylon screws and nuts. **88**

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Polyester Resins. American Cyanamid Co., Plastics & Resins Div., 8 pp, Jan '61. Characteristics, advantages, available types, uses, operating procedures, safety, coloring, and other information on polyester resins for spray-up application. **89**

Corrosion Resistant Plastics. Ceilcote Co., Inc., 4 pp, illus., No. 1-2. Advantages, characteristics, properties, chemical resistance, and uses of corrosion resistant reinforced plastics linings, coatings, floorings, process equipment, cements, and ventilating equipment. **90**

Polyester Resins. Celanese Corp. of America, Celanese Polymer Co. Div., 6 pp, illus., No. M2A. General information and specific properties of a line of polyester resins for automotive parts, tank trucks, boat hulls, architectural panels, furniture, refrigerator doors and storage tanks. **91**

Metallized Mylar. Coating Products, Inc., 6 pp. Series of tip-on samples illustrate the variety of colors, patterns, and special effects available in metallized Mylar. **92**

Floating Structures. Dow Chemical Co., Plastics Sales Dept., 24 pp, illus., No. 32-B (NN). Advantages, limitations, sizes, properties, design information, and typical applications of floating structures made with polystyrene foams. **93**

Silicones in Aircraft. Dow Corning Corp., 8 pp, illus., No. 1-117. Properties and typical uses of silicone fluids, rubber, potting materials, sealants, and protective coatings in aircraft and missiles. **94**

Nylon Tubing. E. I. du Pont de Nemours & Co., Inc., Polychemicals Dept., 8 pp, illus., No. A-12841. Strength, chemical resistance, temperature resistance, compositions of various grades, design information, and typical applications of nylon tubing for the automotive industry. **95**

High Temperature Insulation. Fiberite Corp., 16 pp. illus. Characteristics, properties, molding techniques and uses of a line of variously reinforced plastic compounds for high temperature insulation. **96**

Diallyl Phthalate Compounds. Food Machinery & Chemical Corp., Chemicals & Plastics Div., Dapon Dept., 26 pp. Properties and uses of molding compounds based on diallyl phthalate resins, including physical and electrical properties, chemical and fungus resistance, flame proofing, molds, molding temperatures and pressures, curing time, tests for cure, and the effect of fillers on properties. **97**

Nylon Resins. Foster Grant Co., Inc., Plastics Div., 10 pp, No. N-58-2. Chemical resistance, physical properties and applications for a line of special nylon molding and extruding resins. **98**

New Polyurethane Elastomer. B. F. Goodrich Co., B. F. Goodrich Chemical Co. Div., 16 pp, No. G-18. Physical properties, chemical resistance, processing information, advantages, characteristics, and typical applications of a new polyurethane elastomer. **99**

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High Density Polyethylene. Hercules Powder Co., Inc., 40 pp, illus., No. 500-273A. Information on structure; physical, thermal, electrical, and environmental properties; chemical resistance; typical applications in the electrical, textile, housewares, and packaging industries; and information on injection and compression molding, extruding, vacuum forming, and other methods of fabrication. **104**

Elastomer Compounds. Minnesota Mining & Mfg. Co., Chemical Div., 2 pp, illus. Properties, specifications and uses of a new elastomer compound designed for long time service at 400 F. **105**

Rigid Polyethylene Plastics. Phillips Chemical Co., Plastics Sales Div., 26 pp, illus. Properties, uses and fabricating data for rigid polyethylene resins. **106**

Phenolics. Plastics Engineering Co., 16 pp, illus. General information on phenolic molding compounds, including available colors, range of properties and typical advantages and applications. **107**

Molded, Laminated Plastics. Richardson Co., 12 pp, illus. Information on the facilities and services available for the production of molded and laminated plastics parts. Included are a series of typical applications. **108**

Acrylic Molding Compound. Rohm & Haas Co., 8 pp, illus., No. PL-363. Physical properties, chemical resistance and uses of a modified acrylic for injection molding and extrusion. **109**

Plastics Laminates. St. Regis Paper Co., Panelyte Div., 18 pp, illus. Colors, finishes, sizes, thicknesses, strength properties, tolerances, electrical properties, typical applications, and other data on a variety of industrial plastics laminates. **110**

Polystyrene. Shell Oil Co., Shell Chemical Co. Div., 2 pp, No. SC-60-100. Information on facilities and services available for the production of polystyrene compounds for molding, extruding, and vacuum forming. **111**

Fabricating Plastics Parts. Sinko Mfg. & Tool Co., 4 pp, illus. Facilities for injection molding, vacuum distillation plating, hot stamping, painting and assembly of plastics parts. **112**

Plastics Laminates. Spaulding Fibre Co., Inc. General descriptions, characteristics, and specifications of 15 different phenolic, epoxy, melamine, and polyester fire resistant industrial plastics laminates. Includes information on copper-clad materials. **113**

Plastisols, Organosols. Union Carbide Corp., Union Carbide Plastics Co. Div., 24 pp, illus., No. J-2148. General information on vinyl dispersions, including formulation of plastisols and organosols; use of plasticizers, coloring pigments, and fillers; storage and handling; flow properties; and typical uses for spread coating, foaming, dip coating, molding, and spray and extrusion coating. **114**

ABS Plastics. United States Rubber Co., Naugatuck Chemical Div., 28 pp, illus. Complete physical, electrical, and chemical properties; processing information; finishing operations; and a series of typical applications of ABS plastics. **115**

Other Nonmetallics • Parts • Forms

Felt Application Guide. American Felt Co., 8 pp, illus. Information on 800 types of industrial and decorative felts, including typical applications for each type. **116**

Felt. Continental Felt Co. Information on wool, synthetic fiber and colored felts. **117**

Felt Design Book. Felters Co., 24 pp. Information on design properties of felt, descriptions of special treatments, and data on how to select the proper shapes and dimensions for specific applications. Also included are data on felt lubrication seals, gaskets, wicking and filters. **118**

Wood Products. Gamble Brothers, Inc., 28 pp, illus. Shows wood products manufactured by the company, including industrial wood parts, chair parts and athletic apparatus. **119**

Graphite. Great Lakes Carbon Corp., Electrode Div., 8 pp, illus. Outstanding characteristics, chemical composition, properties, and typical applications of graphite in atomic energy, metallurgy, metal fabricating, aircraft and missiles, chemical processing, etc. 120

Specialty Papers. Knowlton Bros., Inc., 12 pp, illus. Information on technical and industrial specialty papers. Shows company research and manufacturing facilities. 121

Industrial Ceramics. McDanel Refractory Porcelain Co., 4 pp, illus. Briefly describes ceramic pump pistons, combustion tubes, heat reflectors, crucibles and liners. 122

Carbon Graphite. Pure Carbon Co., Inc., 12 pp, illus., No. 55. Catalog on carbon graphite for mechanical applications. 123

Thermal Insulation. H. I. Thompson Fiber Glass Co., chart. Information on thermal insulations for temperatures from —300 F to 3000 F. 124

Synthetic Fiber Felts. Troy Mills, Inc., Industrial Div., 8 pp, illus. Strength, dimensional stability, wear, moisture and chemical resistance, and uses of a nonwoven synthetic fiber felt. 125

Single Crystal Refractories. Union Carbide Corp., Linde Co. Div., 4 pp, illus., Nos. F-1397, 1398, 1400. General descriptions, physical properties, sizes, and other information on single crystals, tungsten, molybdenum, vanadium, columbium, and tantalum; and various titanium and molybdenum compounds. 126

Sintered Metallic Oxides. U. S. Stoneware Co., Alite Div., 8 pp, illus., No. A-7R. Electrical characteristics, size limitations, dimensional tolerances, chemical and heat resistance, and physical properties for a series of sintered metallic oxides called Alite. 127

Finishes • Cleaning & Finishing

Corrosion Inhibitor. Allied Chemical Corp., Solvay Process Div., 17 pp, illus. Use of sodium nitrite in corrosion prevention. 128

Chromium Diffusion Coating. Alloy Surfaces Co., 24 pp, illus., No. CW 6-60. Information on a new process for diffusing chromium into stainless steel. Includes a description of the process and equipment, and characteristics, properties, costs, and typical applications of coated steel. 129

Diffusion Coating of Chromium. Chromalloy Corp., 1 p, No. 34. Test results obtained on molybdenum protected with a chromium diffusion coating. 130

Spray Painting. Conforming Matrix Corp., 2 pp, illus. Information on a paint spray machine and an automatic rotary wiping machine for use in spray mask decoration. 131

Magnesium Finishing. Dow Chemical Co., Dow Metal Products Co. Div., 8 pp, illus., No. 143-267. Article discusses principles of corrosion and how to protect magnesium and its alloys. 132

Silver Plating Process. Engelhard Industries, Inc., American Platinum & Silver Div., 12 pp. Characteristics, advantages, operating conditions, deposition rates, and other information on a silver plating process. 133

Metallized Ceramic Coating. Frenchtown Porcelain Co., 4 pp, illus. Data on Molcote, metal-to-ceramic coating, that may be hard soldered up to 2200 F. 134

Multicolor Enamel. Maas & Waldstein Co., 2 pp, No. 520. Data sheet for industrial multicolor enamels. 135

Hard Surfacing Electrodes. Metal & Thermit Corp., Unichrome Finishes & Welding Prod. File cards give data on 88 types and sizes of hard surfacing electrodes and rods. 136

Fusion Coatings. Michigan Chrome & Chemical Co., Chemical Div., 6 pp, illus. Information on small particle size plastics powders for use in fluidized bed coatings. Information also on equipment for fluidized bed coating. 137

Silicone-Base Coatings. Midland Industrial Finishes Co., 4 pp, illus. Heat, chemical and corrosion resistance, application data and uses of silicone-base coatings. 138

Metal Cleaners. Northwest Chemical Co., 4 pp. Information on immersion, electrolytic and spray cleaners for die castings, steel, copper and aluminum. 139

Ceramic Spray Coatings. Norton Co., Refractories Div., 8 pp, illus., No. H-3-1. Describes methods of mounting temperature and strain measuring elements by means of ceramic spray coatings. 140

Metal Cleaner. Oakite Products, Inc., 2 pp, illus., No. 17B. Advantages, characteristics, and other information on a strongly alkaline cleaner designed to handle steel, iron, brass, magnesium, and other metals. 141

Conversion Coatings. Parker Rust Proof Co., 4 pp, illus., Jan-Feb '61. Series of typical applications indicate advantages and characteristics of conversion coatings for steel and aluminum. 142

Joining & Fastening

Silver Brazing Alloys. Air Reduction Sales Co., Div. of Air Reduction Co., Inc., 24 pp, illus., No. ADC-847C. General description of brazing process, advantages of silver alloys, procedures, selection of base and filler metals, design of brazed joints, specifications, available alloys, and other information on silver brazing. 143

Adhesives for Mylar. E. I. du Pont de Nemours & Co., Inc., Industrial Finishes Div., Fabrics & Finishes Dept., 8 pp, illus., No. 17. Classes of adhesives, characteristics, advantages, properties, methods of application, and typical uses of adhesives for Mylar polyester film. 144

Lock Washer Selection. Shakeproof Div., Illinois Tool Works, 12 pp, illus., No. AS-105. Information on how to select the right lock washer to meet specific requirements. Includes advantages of each type of standard lock washer and a list of applications for which each is best suited. 145

Bolts, Forgings. Rhode Island Tool Co., 26 pp, illus., No. 75. Dimensions, properties, prices and uses for drop and upset forgings, eye and special bolts, studs, cap screws, and nuts. 146

Screws. Russell, Burdsall & Ward Bolt & Nut Co., 8 pp, illus. Advantages and specifications of Spin-Lock screws available in hex, pan, truss or flat heads. 147

Silicon Nitride. Union Carbide Corp., Haynes Stellite Co., Div., 8 pp, illus., No. F-30114A. Properties, characteristics, design considerations, and typical applications of temperature and corrosion resistant silicon nitride. 148

Methods & Equipment • Testing

Hardness Tester. Wilson Mechanical Instrument Div., American Chain & Cable Co., Inc., 2 pp, illus., No. TT-58. Dimensions, features, operational data and prices of a Rockwell hardness tester. 149

Fatigue Testing Machine. American Machine & Metals, Inc., Riehle Testing Machines Div., 12 pp, illus., No. RF-2-61. Advantages, characteristics, specifications, procedures, uses, and other information on a fatigue testing machine. 150

Processing X-Ray Films. Eastman Kodak Co., X-Ray Sales Div., 6 pp, illus. Describes an entirely new system of faster, better processing for industrial x-ray film. 151

Vibration Dampeners. Firestone Industrial Products Co., Div. of Firestone Tire & Rubber Co., 32 pp, illus. Design data and technical information on vibration dampeners. 160

Vibratory Machines. King Seeley Thermos Co., Queen Products Div., illus. Information on seven vibratory machines used for high-speed finishing of stampings, castings, forgings and machine parts. 161

Cold Cabinet. Revco Inc., Industrial Products Div., 2 pp. Low temperature cabinet for industrial processes and research. 152

Tensile Elongation Tester. Scott Testers, Inc., 5 pp, illus., No. HCG-1276. Characteristics, advantages, specifications, uses, and other information on a constant rate of extension tensile elongation tester. 153

Testing Services. Foster D. Snell, Inc., 16 pp. Information on services and facilities available for product research and development, product improvement, product application, comparative testing, market research, product and process control, etc. 154

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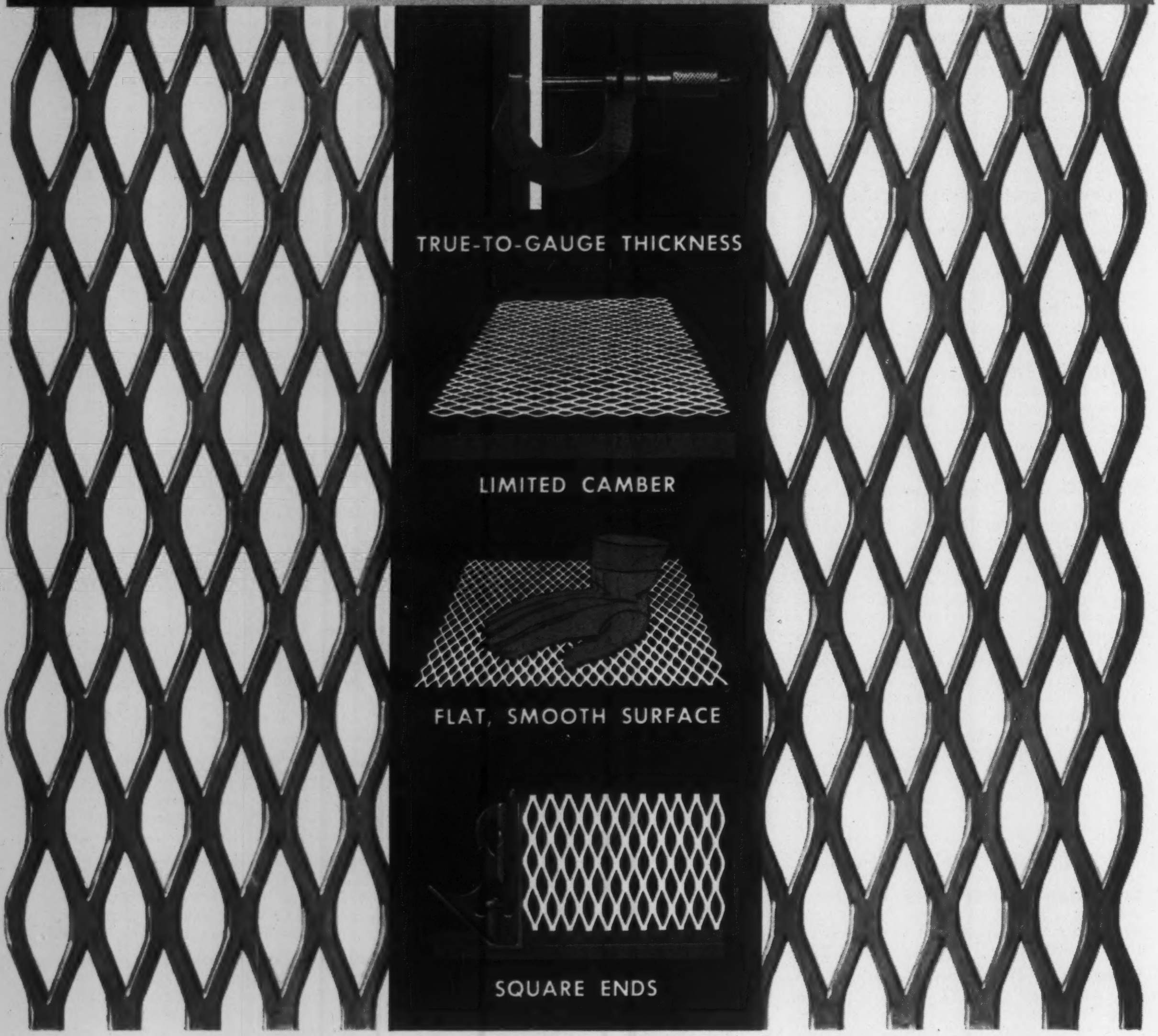

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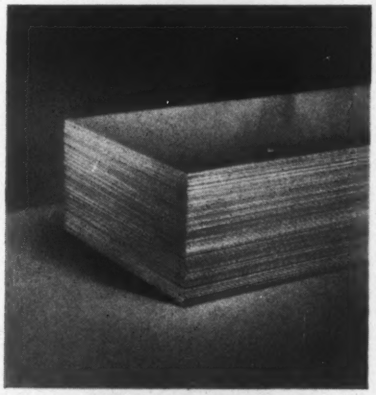

Wheeling Long Terne is available in widths to 48". It is normally supplied with either commercial or special terne coatings.

(cont'd from p 51)

Books

The Physical Examination of Metals, 2nd Ed. *Edited by B. Chalmers and A. G. Quarrell. St. Martin's Press, Inc., New York. 1961. Cloth, 6 by 9 in. Price $30*

Reviewed by George L. Kehl*

The first edition of this authoritative book, which consisted of two volumes (published in 1939 and 1941, respectively), has now been completely revised, expanded and combined into a new single volume.

Ten new chapters

To make this second edition more comprehensive and complete, ten new chapters have been added on the following subjects: thermal methods, magnetic analysis, neutron diffraction, radiation methods, damping capacity of metals, measurements of elasticity using mechanical waves, ultrasonic flaw detection, ferrographic method of flaw detection, radioactive isotopes and their application in metallurgy, microradiography and autoradiography, and, a most welcome but too brief discussion of modern vacuum techniques. The chapter on radiography has been dropped.

Unlike the first edition, the new single volume has been compiled from contributions by 18 scientific specialists, of which 16 are from within the British Commonwealth. It is therefore not surprising to find that (for the most part) the text material is presented clearly and comprehensively—as is so typical of British scientific writing.

Pure science discipline

The concept of the second edition, as proposed by the editors, follows the principle that today's scientifically trained metallurgist is more acutely aware of, and in many cases more familiar with, the pure science discipline than was his predecessor. He therefore possesses a greater appreciation of physical principles and modern techniques, and believes that any technique that can contribute to a better understanding of metals is potentially a metallurgical technique.

The subject matter of each chapter is presented in logical sequence: there is first a general discussion of the scientific principles involved (in some chapters unnecessarily lengthy); following this are applications of the principles to metallurgical measurements for which they are best adapted; and finally, the text cites specific examples of the applied technique. Each chapter concludes with a useful reference list; some of these are rather extensive.

Basic study of principles

This book is not intended for use as a teaching textbook or handbook. It is intended primarily for those whose interests lie in the basic study of metals and who, therefore, must understand the principles involved in the various techniques of the physical examination of metals.

Electronic Packaging with Resins. *Charles Harper. McGraw-Hill Book Co., New York. 1961. Cloth, 6 by 9¼ in., 339 pp. Price $11*

Subtitled "A Practical Guide for Materials and Manufacturing Techniques," this book presents an introduction to the materials, methods and techniques employed in electronic packaging. Among the materials covered are polyesters, silicones, epoxies, urethanes, and polysulfides; among the techniques covered are casting, potting, impregnating, and encapsulating of electrical and electronic components and systems.

Other subjects covered include fillers, colorants and modifiers; foams and low-density compounds; thermally and electrically conductive compounds; effects of extreme environments; tools, fixtures and finishing operations; processing equipment; and manufacturing controls.

Advances in Cryogenic Engineering, Volume 6. *Edited by K. D. Timmerhaus. Plenum Press, Inc., New York. 1961. Cloth, 6½ by 10¼ in., 662 pp. Price $15*

Consisting of the Proceedings of the 1960 Cryogenic Engineering Conference, this book presents a summary of the year's most significant developments in the field of cryogenics. The papers discuss such things as the progress made in space technology, superconductivity, transfer phenomena, physical equilibria, cry-

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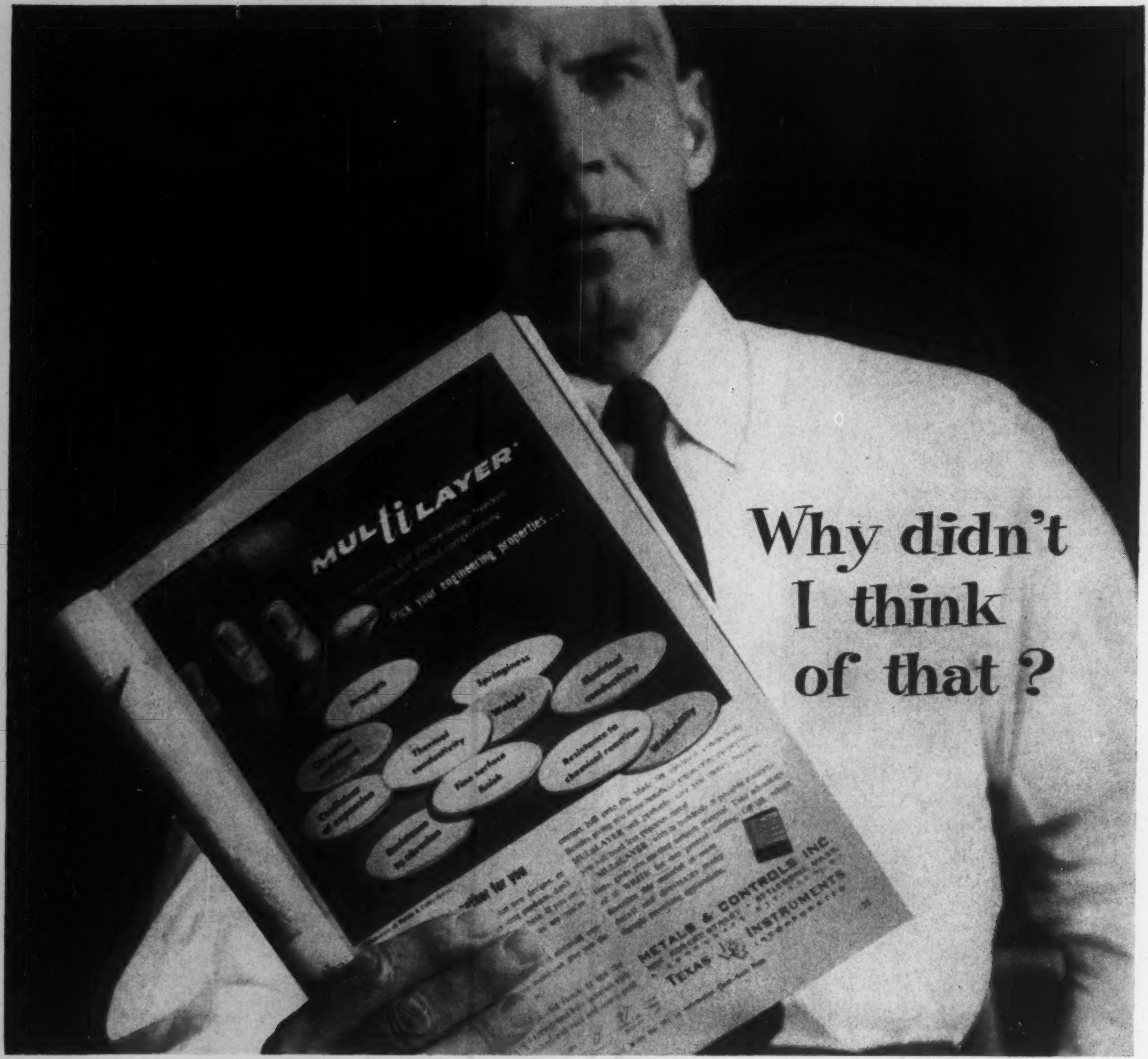
* Professor of Metallurgy, School of Mines, Columbia University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ogenic equipment, mechanical properties, and heat transfer and thermometry.

Progress in Very High Pressure Research. *Edited by F. P. Bundy, W. R. Hibbard, Jr., and H. M. Strong. John Wiley & Sons, Inc., New York. 1961. Cloth, 8½ by 11¼ in., 314 pp. Price $12*

This book consists of papers and discussions presented at a recent international conference jointly sponsored by Materials Central, Wright Air Development Div., U. S. Air Force, and General Electric Co. Major emphasis is on equipment and techniques, structures of materials formed under high pressure, and behavior of matter under high pressure. Of special interest is a review of high pressure work in the USSR, presented by a noted Soviet scientist. Other papers cover such subjects as the problem of absolute pressure calibration, and the optical, electrical, and magnetic changes in materials resulting from the decrease of interatomic or intermolecular distances.

Reports

Explosive forming Explosive Metalworking. *Defense Metals Information Center, Battelle Memorial Institute. Nov '60. 30 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price 50¢ (PB 161 221)*

Discusses principles of explosive forming, its effect on material properties, possible applications, and advantages.

Platinum metals High Temperature Properties and Alloying Behavior of the Refractory Platinum-Group Metals. *R. W. Douglass, F. C. Holden, and R. I. Jaffee. Battelle Memorial Institute. Aug. '59. 118 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $2.75 (PB 161 823)*

Results of a literature survey of the platinum-group metals. Major emphasis is on rhodium, iridium, osmium, and ruthenium; however, platinum and palladium are included. Discusses process metallurgy, and physical, chemical and metallurgical properties. A bibliography and list of references is included.

Ceramic coatings Heat Fused Ceramic Coatings for Aluminum Components of Rocket Launchers. *T. Rice and T. Turner. Rock Island Arsenal Laboratory, Ordnance Corp. Oct '60. 15 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D.C. Price 50¢ (PB 171 074)*

Ceramics coatings containing lead-bearing and lead-free frits were prepared from commercially available materials and applied to aluminum test panels. The coatings provided excellent heat resistance, but were deficient in abrasion resistance.

Welding columbium Welding of Columbium and Columbium Alloys. *Defense Metals Information Center, Battelle Memorial Institute. Oct '60. 28 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price 50¢ (PB 161 219)*

Although welding information on columbium and its alloys is limited, this report attempts to summarize what information is available. The approach is to evaluate known metallurgical characteristics and to then use this data to anticipate specific problems that may be involved in welding.

Steel extrusions Availability and Mechanical Properties of High Strength Steel Extrusions. *Defense Metals Information Center, Battelle Memorial Institute. Oct '60. 60 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $1.75 (PB 151 097)*

Six types of steels are considered. Includes current specifications, typical mechanical properties, and anticipated requirements.

Radiation effects Radiation Effects Upon and the Recovery of the Mechanical Properties of Metals. *E. N. Aqua and R. J. Allio, Atomic Energy Commission. Oct '60. 33 pp. Available from Office of Technical Services, Dept. of Commerce, Washington 25, D. C. Price $1 (KAPL-2103)*

Molybdenum, steel, nickel and titanium were subjected to various doses of irradiation and tested for mechanical property change and recovery. Results of tests included the discovery that irradiation damage rate is a function of the type of radiation, flux, total dose, and exposure to temperature, and is dependent on the prior history and composition of the specimen. Mechanical property damage is a two-stage process comprising dislocation source hardening and lattice hardening. The mechanism of recovery consists of the migration of polyvacancies to clustered interstitials, or the dissipation of vacancy clutters.

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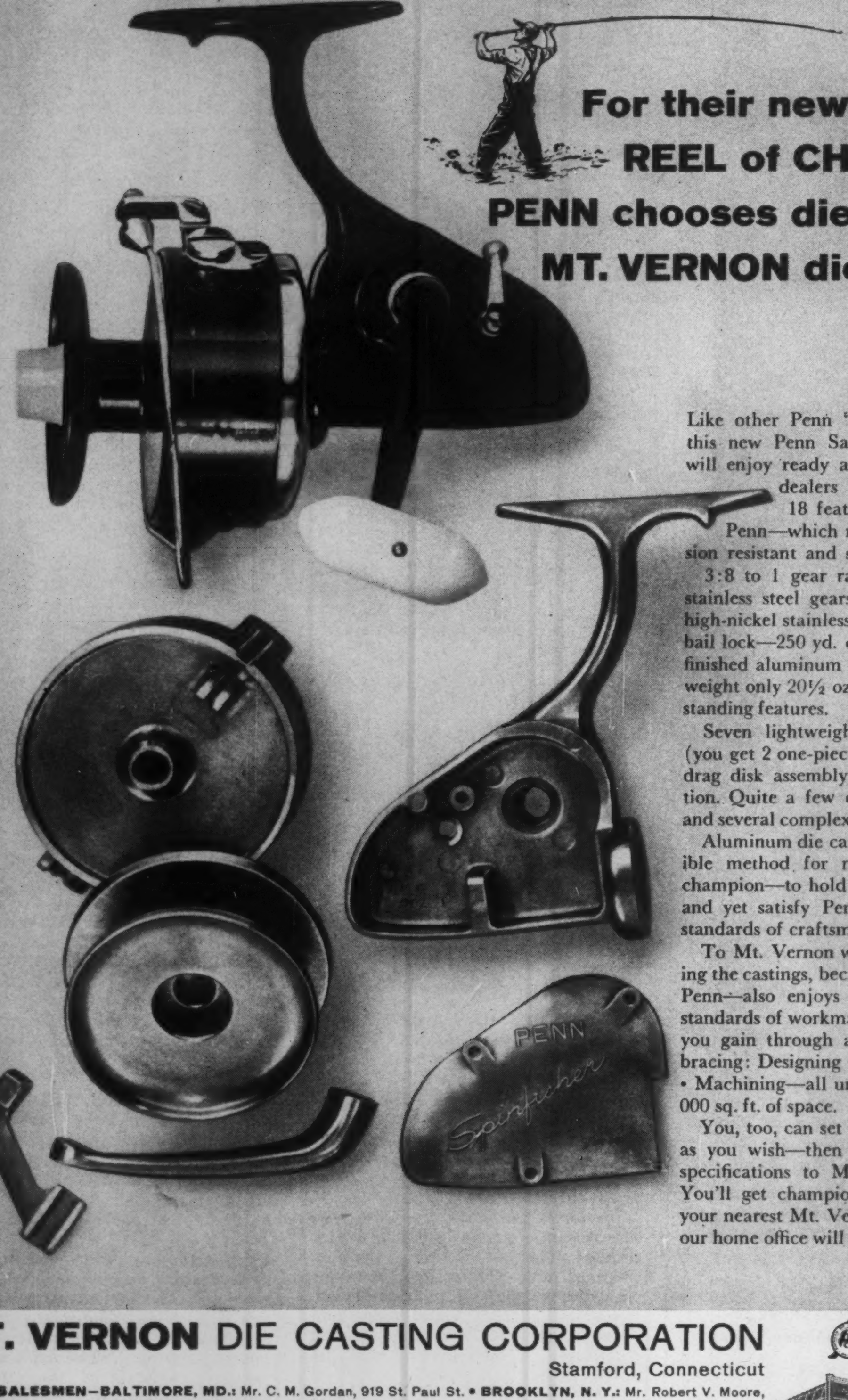

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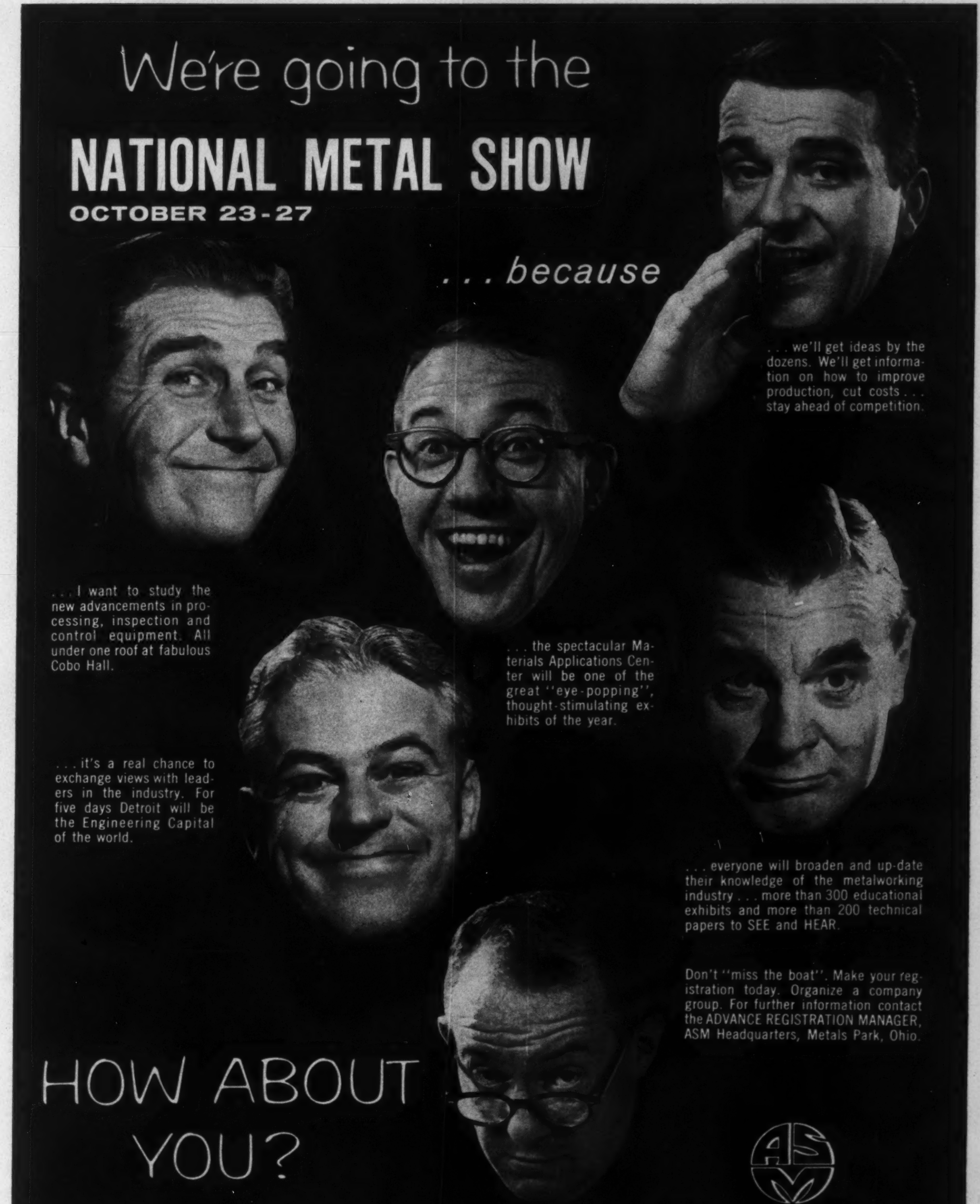

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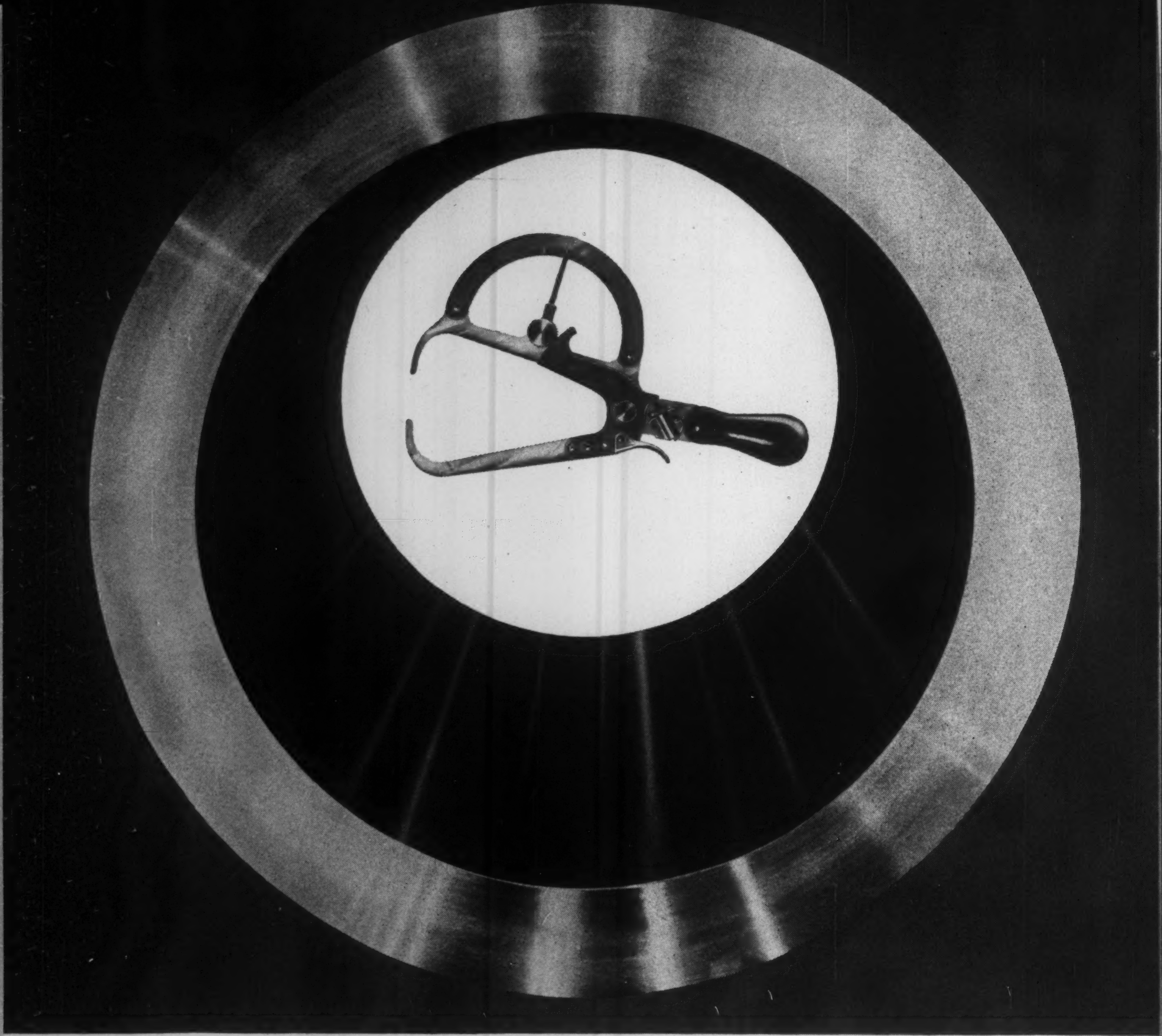

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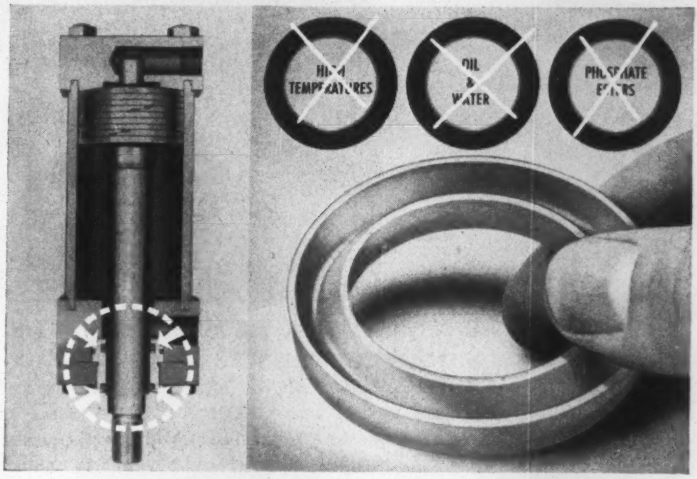

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WITHSTANDS HEAT, COLD! Continuous service may be at temperatures up to 400°F., short-term peaks may exceed 600°F. Gehman stiffness T_{10} is 3°F. Thin sections may be bent without cracking at temperatures as low as -50°F.

LOW COMPRESSION SET! This property of Fluorel Elastomer ranges from 10% after 70 hours at 250° F. to 47% after 70 hours at 400° F.

PHYSICAL PROPERTIES. Fluorel Elastomer can be compounded to provide a wide range of desirable physical characteristics. Properties based on Chicago Rawhide's Compound No. Sirvene 429133 . . .

Specific gravity	1.87
Tear strength	190 lb./in.
Tensile strength	2,000 psi
Elongation	350%
Hardness (Shore A)	80
Fluorine by weight	60%

ELECTRICAL PROPERTIES. Typical stock provides dielectric strength (short time) of 630 volts per mil, a dielectric constant of 11.4, D.C. resistivity of 2×10^{13} ohms cm. at 50% relative humidity, and a dissipation factor of .0125.

APPLICATIONS. Fluorel Elastomer is recommended for seals and O-rings, diaphragms, fuel and hydraulic hose, brake cups, fuel cells, fire walls, pump and tank liners, air ducts, wire insulation, many other uses.

For full information on Fluorel Elastomer, return coupon, or write describing your area of interest.

"FLUOREL" is a reg. TM of 3M Co.

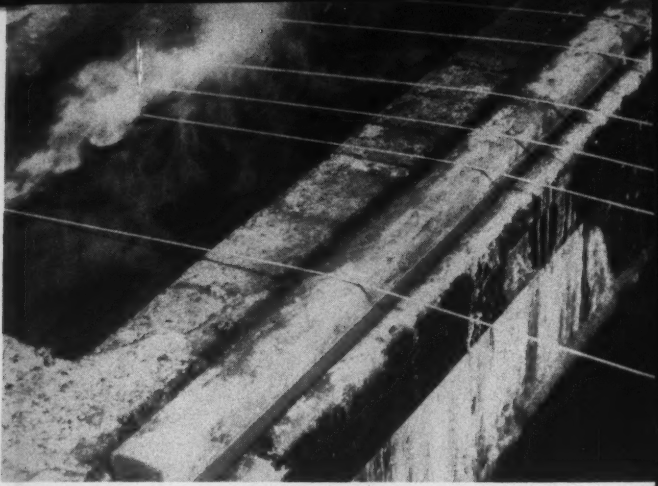
CHEMICAL DIVISION
MINNESOTA MINING AND MANUFACTURING COMPANY
. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY

For more information, turn to Reader Service card, circle No. 470

Report from Carborundum:

6 ways to do jobs better with refractory materials



HANDLING MATERIALS IN ACID SOLUTIONS:

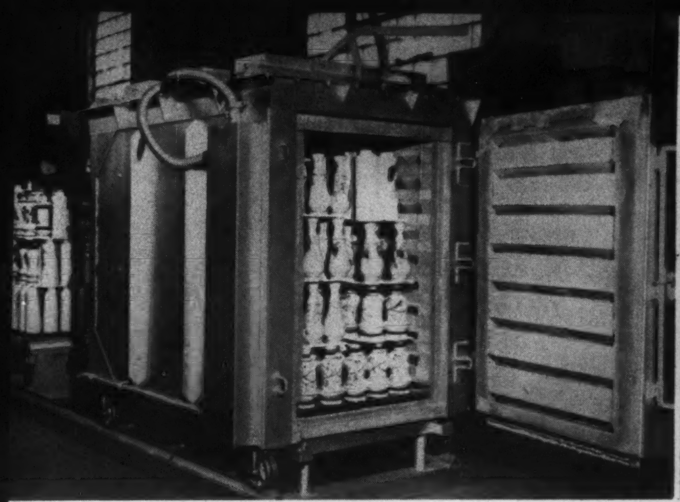
SILICON CARBIDE WEAR BLOCKS RESIST CORROSION AND ABRASION. Steel wire moving at 100 ft/min passes over CARBOFRAX® silicon carbide wear blocks to a pickling tank in the photo above. A 15% solution of sulfuric acid at 400 F is used. Sinker blocks are also of CARBOFRAX silicon carbide. Despite the action of the acid and the abrasion of the wire, the silicon carbide shows no wear after months of service. Similar applications involving Carborundum refractories are found in aluminizing and other wire coating baths.

SKID RAILS IN REHEAT FURNACE:

SILICON CARBIDE RAILS LAST 30 TIMES AS LONG AS STEEL IN HIGH TEMPERATURE, ABRASIVE SERVICE. The 6¾" x 8" brass billets seen in the picture are pushed through a 38-foot long gas-fired extrusion mill furnace. Steel skid rails required replacement every five weeks. When CARBOFRAX silicon carbide rails were installed, 156 weeks of service were obtained. Reduction in downtime resulted in lower operating costs and higher production rates. Superior wear resistance and ability to withstand high temperatures make silicon carbide a profitable choice for applications like this.

LONGER LIFE FOR BURNER RINGS:

SILICON CARBIDE CONSTRUCTION WITHSTANDS FLAME EROSION AND HIGH TEMPERATURES. Refractory burner rings in pulverized coal-fired boiler frequently fail fast because of the abrasive action of the fuel particles and thermal shock due to intermittent operation. Many users have found an answer to the problem in CARBOFRAX silicon carbide rings. Silicon carbide is not only superhard, but also stays hard at high temperatures. High thermal conductivity and resistance to thermal shock minimizes cracking and spalling. Flame patterns are maintained.

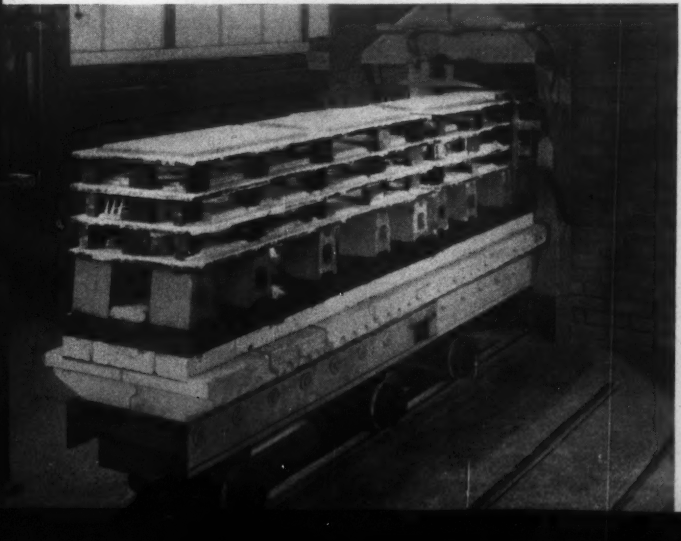


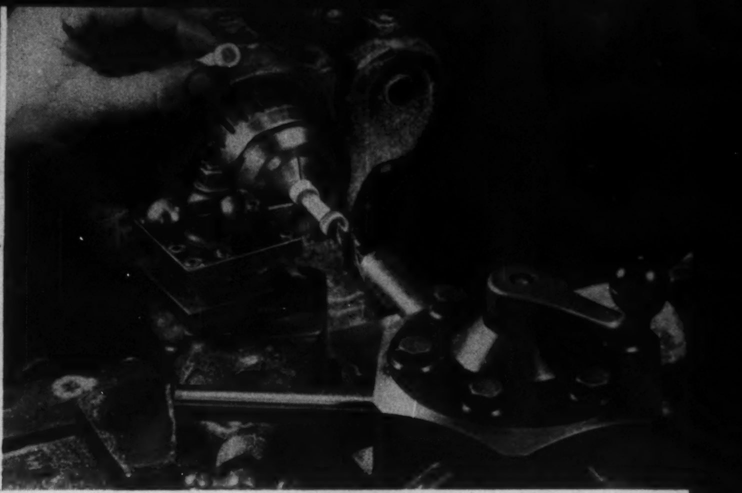
DIRT-FREE OPEN FIRING WITH MOVABLE KILN:

FIBERFRAX® CERAMIC FIBER LINING REPLACES BRICK: MAKES POSSIBLE TEMPERATURES UP TO 2200 F. The interesting movable kiln illustrated is made by Unique Kiln Co., Hillsdale, N. J. It moves on rails to enclose a stationary loading bed. Two beds can be serviced alternately. Door and hood linings of Carborundum's light-weight FIBERFRAX ceramic fiber, in block form, eliminate the problem of dislodged dirt and dust encountered with fireclay type refractories, which often damage ware being fired. High heat resistance and insulating properties of FIBERFRAX fiber make possible firing up to 2200 F.

ELIMINATING CRACKING IN KILN CAR TOPS:

COMBINATION OF REFRACTORIES SOLVES PROBLEM IN CERAMIC INDUSTRY. Used in a gas-fired electrical porcelain kiln, the cars illustrated have been in service for more than two years at cycles of 14 to 15 hours, operating from cold to 2290 F to cold. Car top cracking due to heat shock has been eliminated by use of three different Carborundum refractories—a bottom layer of MULLFRAX® electric furnace mullite for high load carrying capacity, a middle course of ALFRAX® alumina "bubble" brick for insulation and an upper course of CARBOFRAX silicon carbide tile for resistance to thermal shock.





SHAPES AND JIGS MACHINED FROM CERAMIC:

BORON NITRIDE IS EASILY MACHINED; RESISTS HIGH TEMPERATURES AND CORROSION. The photo shows the machining of a semi-conductor jig from Boron Nitride, a self-bonded material made by Carborundum. Close tolerances, high surface finish and intricate detail are possible. Boron Nitride offers advantages in semi-conductor production compared with graphite jigs, yields from which often drop 40% after only 50 cycles. The material also offers possibilities for insulating tubes and shapes; chemical equipment parts, crucibles, brazing fixtures, gaskets and seals. Shapes withstand furnace temperature of 3000 F; powder as high as 5400 F.

Want help on your problems?

Carborundum engineers will be glad to recommend refractories to answer your specific needs. For information, contact Dept. MD-91, Refractories Division, Carborundum Co., Perth Amboy, N. J. Descriptive brochures available on request. Please specify the area or areas of particular interest to you.

for engineered refractories...count on

CARBORUNDUM®

For more information, circle No. 372

BOND FAILURES CAN BE PREVENTED!

Here's how to stop 13 of them...

Type of Failure	Solution
THERMOSETTING ADHESIVES	
• Cohesive failure	Check film with solvent used in adhesive. If solvent softens the adhesive film or becomes tacky, this indicates insufficient cure. Make sure bond line time and temperature is used.
• Adhesive failure from metal	If metal surface has a white, clean appearance, check cleaning technique.
• Adhesive failure from substrate other than metal	Try prime coat of diluted adhesive, also check compatibility.
• Cellular areas in adhesive line	Increase pressure and/or adhesive.
CONTACT ADHESIVES—room temperature setting	
• Tacky film	If film should dry hard but remains tacky, the cause may be entrapped solvent or migration of plasticizer from one substrate.
• Shiny areas	Poor contact, insufficient pressure or insufficient amount of cement.
• No bond	If heat reactivated type, adhesive was too cool at time of assembly or poor compatibility.
• Failure in adhesive from metal	Improper cleaning.
• Failure from substrate other than metal	Incompatible or unclean surfaces.
HOT MELT	
• No bond	Incompatibility, adhesive too cool at time of assembly. Parts too cool at time of application of adhesive.
EPOXY BASE ADHESIVES AND CASTING COMPOUNDS	
• High exotherm	Mix lower volume and pour mixed material into shallow tray. Cool base and activator before mixing or use Metermixing equipment.
• Tacky film or casting	Improper base activator ratio, improper mixing of base and activator, improper cure. Check bond line temperature.
• Flexible casting or film of rigid adhesive or casting compound	Improper mixing of base and activator, improper base and activator, improper cure. Check bond line temperature.

Bond failures can be prevented! Raybestos-Manhattan's adhesive experts also have solutions to less common causes of bond failures . . . based on more than 20 years' experience in the production of bonded assemblies and the manufacture of adhesives, coatings and sealers. Why not call on them today for the answers to your adhesive problems—no cost or obligation, naturally.

R/M Bulletin No. 700 is packed with helpful technical information on Ray-BOND adhesives. Write for your free copy now.

RAYBESTOS-MANHATTAN, INC.

ADHESIVES DEPARTMENT, Bridgeport, Conn. • Chicago 31 • Detroit 2 • Cleveland 16 • Los Angeles 58

RM

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For more information, circle No. 459 ➤

Allied Chemical

Allied Chemical — Plastics Division

PLASKON ALKYD AND ALKYD (DAP) MOLDING COMPOUNDS

Granular Type

Granular materials are designed for high-speed, fully automatic or semi-automatic molding operations. They include glass and mineral-filled grades. Contacts may be molded in or inserted in a separate procedure.

PROPERTIES
Provide high arc and insulation resistance and dielectric values which are maintained at elevated temperatures and after exposure to heat and humidity. Molded parts have unusually high dimensional stability (minimum after-shrinkage). This, plus the fact they are generally adaptable to rapid production cycles, permits endless reproduction of precision parts.

There are PLASKON Alkyd granular types that conform to the MIL-M-14F specification, Type MAG and, the poly diallyl phthalate type, MDG.

APPLICATIONS
Tube bases and sockets, connectors, tuning devices, transformer parts, potentiometer parts, motor controller parts, auto ignition parts, switch and relay parts.

Putty Type

For encapsulation of small electronic parts where delicate inserts are to be sealed within a protective shell. Molds rapidly at extremely low pressures. Available in soft, putty-like sheets. Easy to handle — no mixing required.

PROPERTIES
For many applications the coefficient of linear thermal expansion will be found similar to popular wire types (their thermal conductivity dissipates heat faster) producing less change in dielectric performance before and after encapsulation. Conform to the MIL-M-14F specification, Type MAG.

APPLICATIONS
Resistors, capacitors, coils, transformers, small electronic devices.

Impact Types

Reinforced with glass fiber for increased impact strength. Combines the electrical qualities typical of Alkyds with the high strength of glass fiber reinforcement. Also retains excellent dimensional stability characteristics of all Alkyd Molding Compound types. Suitable for compression and transfer molding.

Grades available to conform with the MIL-M-14F specification, Type MAI-30 and MAI-60; and MIL-M-19833, Type GDI-30.

APPLICATIONS
Computer parts, synchros, coil forms, terminal blocks, connectors, stand-off insulators, heavy-duty circuit breakers and switch gear.

PLASKON COATING RESINS

A complete line of alkyd, urea, melamine, styrenated alkyd, silicone alkyd, modified phenolic, maleic and ester gum resins for the surface coating and printing industries.

PROPERTIES
Each resin is designed to deliver specific performance characteristics such as gloss, superior gloss retention, chemical and solvent resistance, durability and rapid drying.

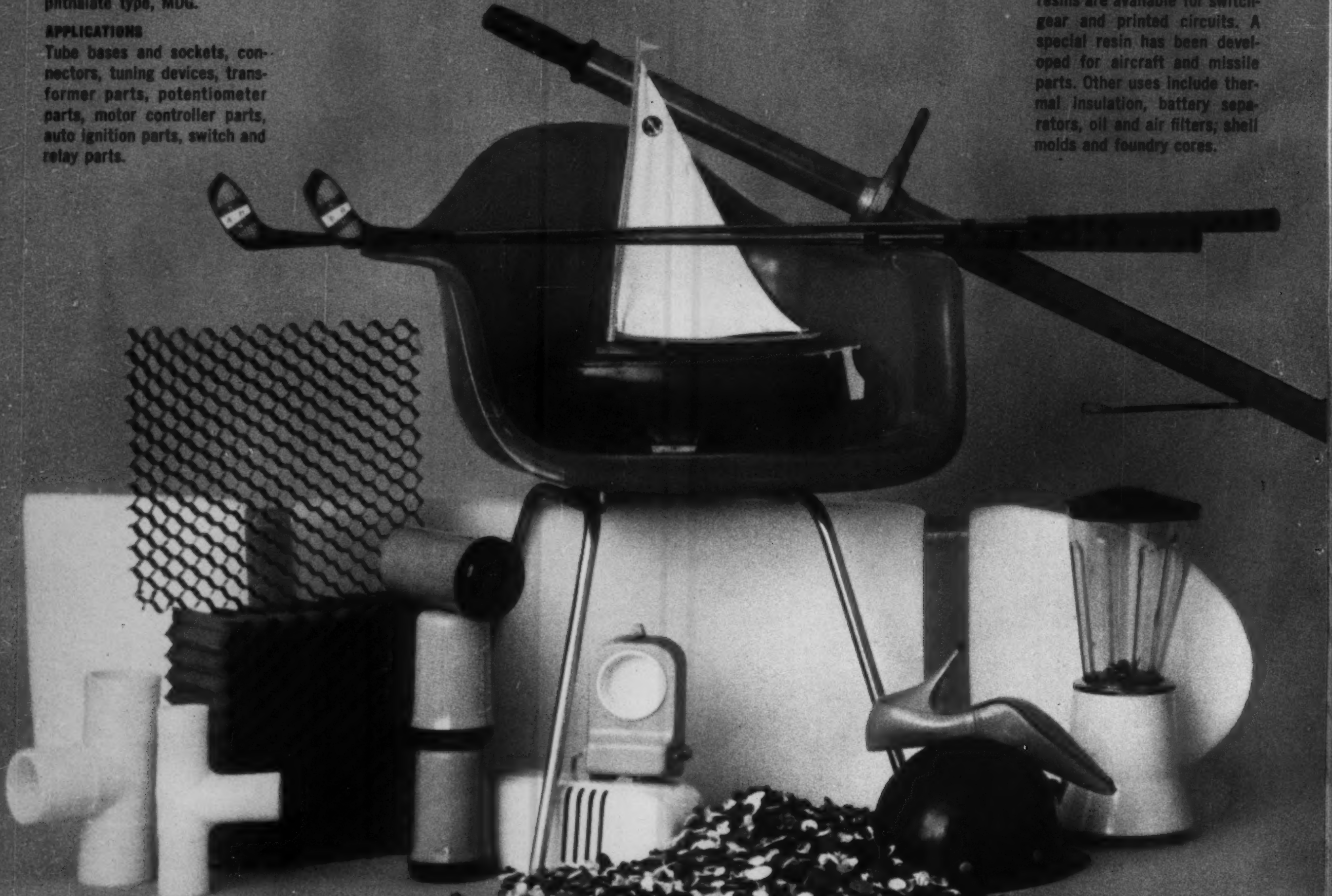
APPLICATIONS
Paints, varnishes, lacquers, printing inks and self-polishing floor waxes. Exterior and interior appliance, automotive and industrial uses.

PLASKON PHENOLIC RESINS

A family of outstanding thermosets. Properly applied, they result in strong, rigid, dimensionally stable products. A new pre-mix resin permits preparation of reinforced molding materials using the economical pre-mix method.

PROPERTIES
Unaffected by water, alcohol, oils, greases, mild acids and common solvents. Excellent heat resistance up to 700°F. when laminated with glass cloth. No marked change at freezing temperatures. Excellent electrical properties. Special grades offer extreme chemical resistance.

APPLICATIONS
Plaskon Phenolic Laminating Varnishes are widely used in decorative and electrical-grade laminates. New flame-retardant resins are available for switchgear and printed circuits. A special resin has been developed for aircraft and missile parts. Other uses include thermal insulation, battery separators, oil and air filters; shell molds and foundry cores.



PLASKON POLYESTER RESINS

A line of specially formulated resins for cost-saving pre-mix molding, which permit rapid production of parts of varying thicknesses, intricate contours or molded-in inserts. Molders can use their own reinforcements, fillers and catalysts.

PROPERTIES

Great strength and light weight in reinforced plastic laminates. "Built-in" molding advantages include pre-acceleration to speed production, rapid impregnation and excellent release for matched-metal molding. Plaskon Polyesters for matched-metal molding offer better mold release, higher gloss and less crazing than general-purpose resins.

APPLICATIONS

Boats, housings, translucent panels, furniture, packaging and aircraft components.

PLASKON HALON* RESINS TYPES VK & TVS

Fluorohalocarbon plastics for difficult design problems. Easily extruded, compression and injection molded. Structure retards crystallization during slow cooling cycles after exposure to high temperatures—tending to maintain toughness, flexibility and clarity.

PROPERTIES

Built-in flexibility, radiation resistance and excellent moldability. Virtually unaffected by inorganic acids, alkalies or oxidizing agents. No moisture absorption. Easy to clean. Excellent optical qualities. Transparent up to ⅛-inch cross section. Resistant to heat and cold: Type VK serviceable up to 350°F., TVS to 390°F. Thin sections can be flexed at —320°F. Good abrasion resistance, impact tensile and compressive strength. High volume and surface resistivity at high and low temperatures. Low dielectric constant and good power factor at high temperatures and frequencies. Nonflammable.

APPLICATIONS

Insulation for hook-up wire, printed circuit boards, flexible cable and cable assemblies. Coil forms, tube sockets, terminal insulators, etc. Lining material for storage tanks, pipe lining, gaskets, "O" rings, etc. Caps for containers of highly corrosive liquids.

PLASKON MELAMINE

A molding compound which provides the hardest surfaces attainable with plastics.

PROPERTIES

Excellent arc resistance, hardness, lightfastness. Inert to chemical and pharmaceutical reagents. Highly resistant to electrical tracking. Tasteless and odorless. Surpasses urea in resistance to acids, alkalies, heat and moisture absorption. Varying degrees of translucency permit unlimited color range.

APPLICATIONS

Dinnerware, appliance housings, electrical parts and wiring devices, cutlery handles and buttons.

PLASKON NYLON-6

New types of molding and extrusion compounds different from previously available domestic nylon. A polymer of caprolactam.

PROPERTIES

Unusual toughness, abrasion resistance, self-lubrication, high heat-distortion temperature, high strength-to-weight ratio and good chemical resistance. Less shrinkage and superior dimensional control than other nylon types. Broader melting range—can be molded at lower temperatures and pressures. Superior impact strength, better moldability in thick sections, easier pigmentation.

APPLICATIONS

Precision parts such as gears, cams and bearings. Small tubing, shapes, small and large rod, film, laminates, wire and rope covering. Parts requiring stability against oxidative embrittlement at high temperatures. Fish line, heel lifts, pipe fittings, pipe, blown bottles.

PLASKON UREA

A molding compound that comes in an extremely wide range of colors — pure white, pastels and brilliant hues. A special housing type has been developed for large parts fabrication.

PROPERTIES

Tasteless, odorless and inert. Resistant to grease, oil, solvents, heat, chipping and cracking. High dielectric strength and arc resistance. Excellent dimensional stability.

APPLICATIONS

Closures, wiring devices, stove and cabinet hardware, toilet seats, lighting fixtures, radio, appliance and other housings, cosmetic and jewelry containers, buttons.

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VARNISH
FLOOR WAX
PAINT
TOLEDO

*Trade Mark

Allied Chemical

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Allied Chemical—Plastics Division

PLASKON FIRE-RESISTANT UREA UFR-28

A molding compound with low flame-spread rating, supplied in unpigmented natural color and a range of tint shades.

PROPERTIES
Self-supporting rigidity. UL flame-spread rating of 25 to 75. Meets fire-resistance requirements of municipal, state and national building codes.

APPLICATIONS
Lighting and appliances. Ideal for luminescent ceilings.

PLASKON WOOD-FLOUR FILLED UREA

An improved general-purpose molding compound available in black, NEMA closure browns and large-volume special opaque colors.

PROPERTIES
Tasteless and odorless. Highly resistant to electrical tracking; excellent arc resistance and insulation properties. Hard; lightfast; inert to chemical and pharmaceutical reagents. Often performs as well as cellulose-filled urea, differing mainly in opacity and color quality.

APPLICATIONS
Wiring devices, switch plates, closures, household circuit breakers and light industrial switch gear.

A-C® POLYETHYLENE 6

A processing aid and modifier for use in injection molding, slush molding and extrusion. By varying the amount of A-C Polyethylene 6, you can tailor the resin melt index to meet any molding problem.

PROPERTIES
Tasteless, non-discoloring. Unusually inert and very stable. Resistant to water, dilute acid solutions, and basic solutions such as ammonium hydroxide and sodium hydroxide. Compatible with most hydrocarbon polymers.

APPLICATIONS
Adding small amounts of AC Polyethylene 6 to high molecular weight resins shortens cycle times by increasing flow, improves color dispersion, improves gloss, permits use of better base resins, improves mold release, lowers pressure requirements and reduces inventory of grades needed.

Plaskon® plastics and resins are backed by the technical proficiency of Allied Chemical's applications and technical service laboratories. They are manufactured under the strictest quality controls. Write us for more information on any of these hard-working materials, or for help with design, fabrication or materials selection problems. 40 Rector Street, New York 6, N. Y.

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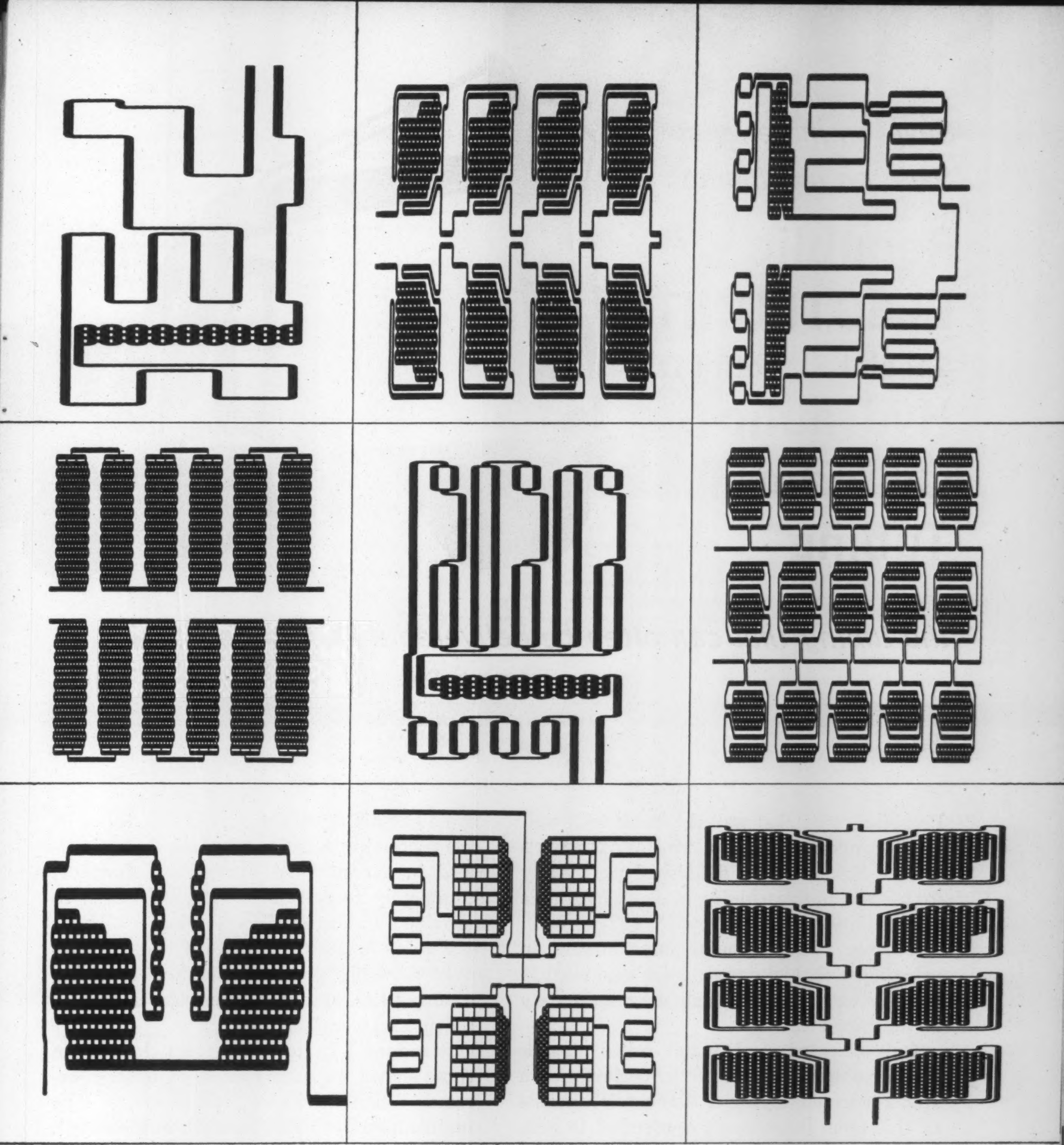
NOTICE: The information herein is presented in good faith, but no warranty is given, nor is freedom from any patent to be inferred.



Any continuous tubing pattern you can create on paper can be put into a homogeneous aluminum or copper ROLL-BOND sheet.

For Brochure write Sales Manager, Roll-Bond Products, Olin Mathieson Chemical Corporation, East Alton, Illinois.

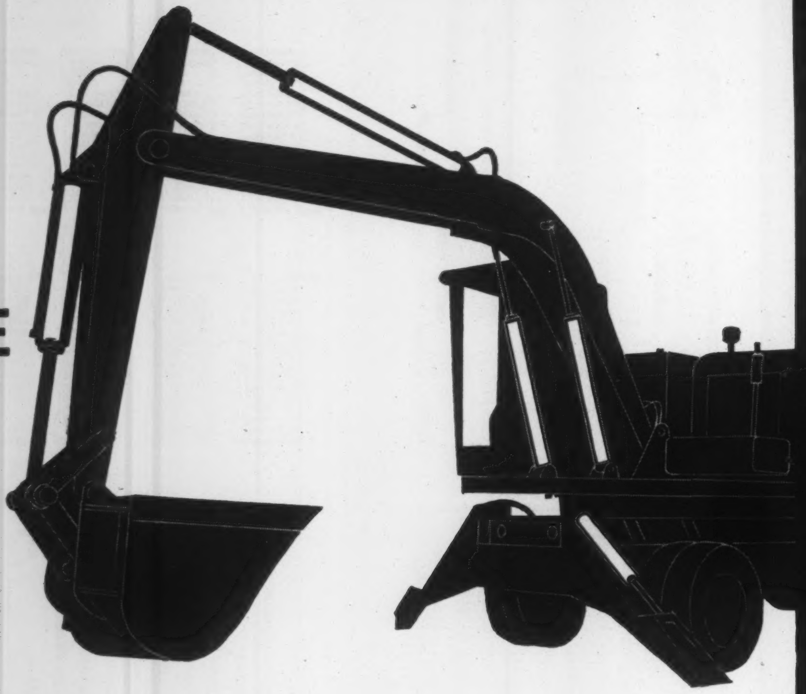
Olin
METALS DIVISION

◀ For more information, circle No. 459

For more information, turn to Reader Service card, circle No. 482

Save on material cost
Save on machining

Republic
ELECTRUNITE
Special Smooth I.D.
Hydraulic
Cylinder
Tubing



the tubing that can often be delivered as a finished part

Precision controlled wall thickness with uniform concentricity makes ELECTRUNITE Special Smooth I.D. a finished part ready for use without machining in many hydraulic applications.

Because you can order ELECTRUNITE in exacting wall thicknesses, there's no need to pay for extra metal which may ultimately be machined away.

Only selected quality flat rolled steel is used in making ELECTRUNITE Special Smooth I.D. Hydraulic Cylinder Tubing. Thickness of this steel is precisely controlled in rolling, assuring uniform wall thickness of the finished tubing.

All tubing is welded by the exclusive ELECTRUNITE process *without addition of extra metal*, assuring that the weld area is of the same chemistry as the rest of the tube. In the processing, lengths of tubing are normalized in a controlled atmosphere furnace, completely recrystallizing the weld area to provide a uniformly ductile tube.

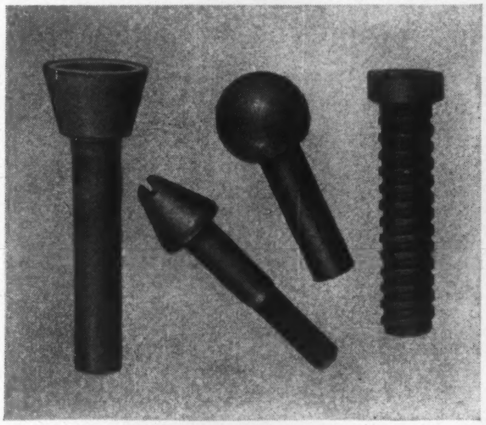
Tubing is drawn through a ring die and over a highly polished mandrel, attaining exacting I.D. and O.D. tolerances as well as a dense I.D. surface finish.

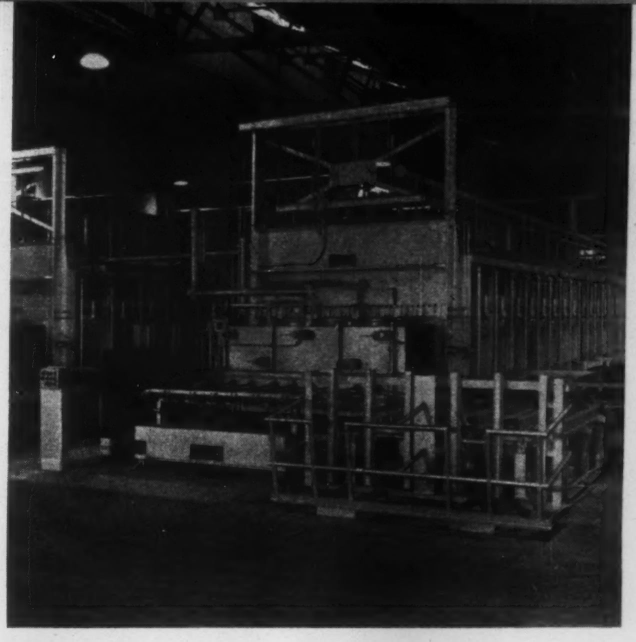
Standard I.D. tolerances are closer than those shown for tubing made by other processes. When necessary, tolerances can be maintained to 50% closer than standard.

For full information on Republic ELECTRUNITE Special Smooth I.D. Hydraulic Cylinder Tubing, Republic Hydraulic Fluid Line and Mechanical Tubing contact your Republic representative or write direct.

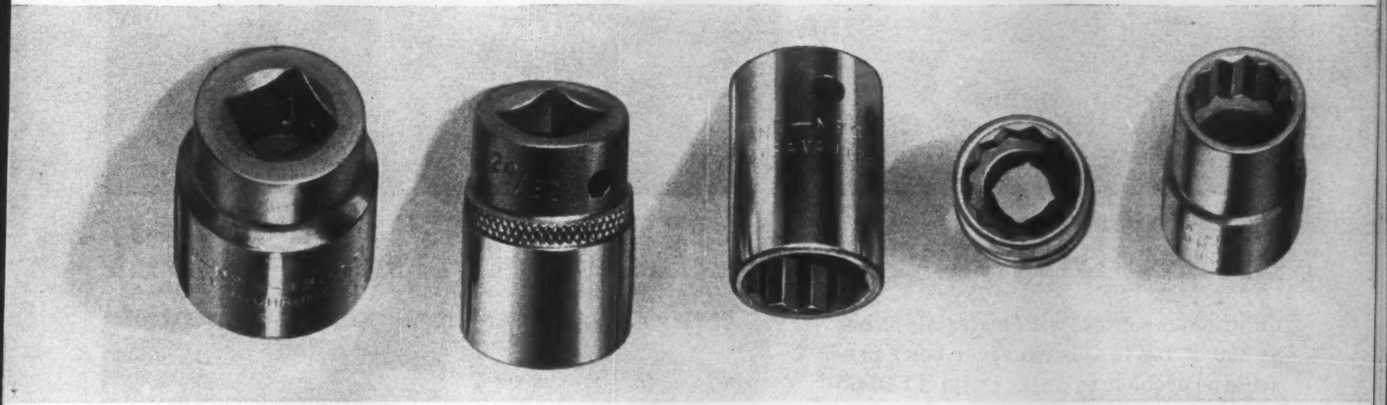
Strong, Modern, Dependable Steel

PROBLEM-SOLVING KNOW-HOW AND EXPERIENCE have made Republic a leader in custom production of Fastener and Formed Parts "Specials." Whenever standard fasteners or formed parts can't do the job, you'll save time and money by contacting Republic. Republic will handle the complete job—design, engineering, and production—or any phase of it. Extensive capabilities result from modern forming, extruding, and upsetting equipment plus complete machining, heat treating, and surface finishing facilities. Send coupon for data.





STEEL FOR COLD EXTRUSION, supplied in heavier coils weighing up to 1600 pounds is produced in Republic's New 11″ Chicago Bar Mill. Atmosphere controlled continuous annealing furnaces can anneal, normalize, or spheroidize to your precise requirements. The cold extrusion process virtually eliminates raw waste material. Standard equipment may be available to minimize your re-tooling costs. Mail coupon for data.



WRENCH SOCKETS, made by Herbrand Division of The Bingham-Herbrand Corporation, Fremont, Ohio, illustrate the kind of application where the superior strength, toughness, and machinability of *Republic Cold Finished Alloy Bars* help produce a better product at lower cost.

Bars are formed, drilled, and cut off in an automatic screw machine, then hot broached to shape internal dimensions. Final stages of socket production include heat treat and chrome plating. Mail coupon for more data on Republic Alloy Bars.

REPUBLIC
STEEL

REPUBLIC STEEL

REPUBLIC HAS THE FEEL FOR MODERN STEEL

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REPUBLIC STEEL CORPORATION
DEPT. ME-2576-A
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

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☐ ELECTRUNITE® Special Smooth I.D. Hydraulic Cylinder Tubing
☐ Republic Steel for Cold Extrusion
☐ Republic Alloy Steel
☐ Republic Fasteners and Formed Parts "Specials"

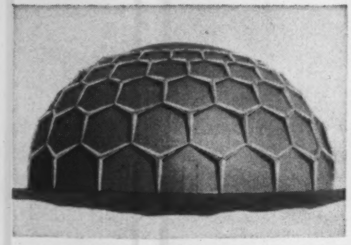
Name____________________Title__________
Company____________________________
Address____________________________
City_________________Zone____State_______

What's News in Rubber...

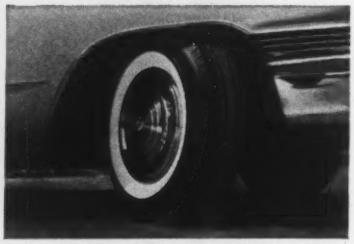
ENJAY BUTYL BEATS HEAT–WEATHER–WEAR

Continuous contact with materials as hot as 350°F (as in this conveyor belt) presents no problem to Enjay Butyl HT 10-66 when properly compounded for heat resistance. Actual service shows that other grades of Enjay Butyl also have exceptional resistance to high-temperature aging in ordinary atmospheres, oxygen or super-heated steam.

For application data, or for technical assistance in applying Butyl, write to Enjay, 15 West 51st Street, New York 19, New York.



Lightweight, durable, permanently flexible and applied cold, this colorful new roofing system at Longway Planetarium in Flint, Mich., takes full advantage of the unusual flexibility and non-hardening properties of Enjay Butyl.



New Enjay Butyl HT 10-66 adds toughness to air-holding innerliners which help assure correct inflation pressure on tubeless tires; gives greater blowout protection and improved tire-tread wear. Also used for sidewalls and chafer strips.

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY CHEMICAL COMPANY

A DIVISION OF HUMBLE OIL & REFINING COMPANY

ENJAY

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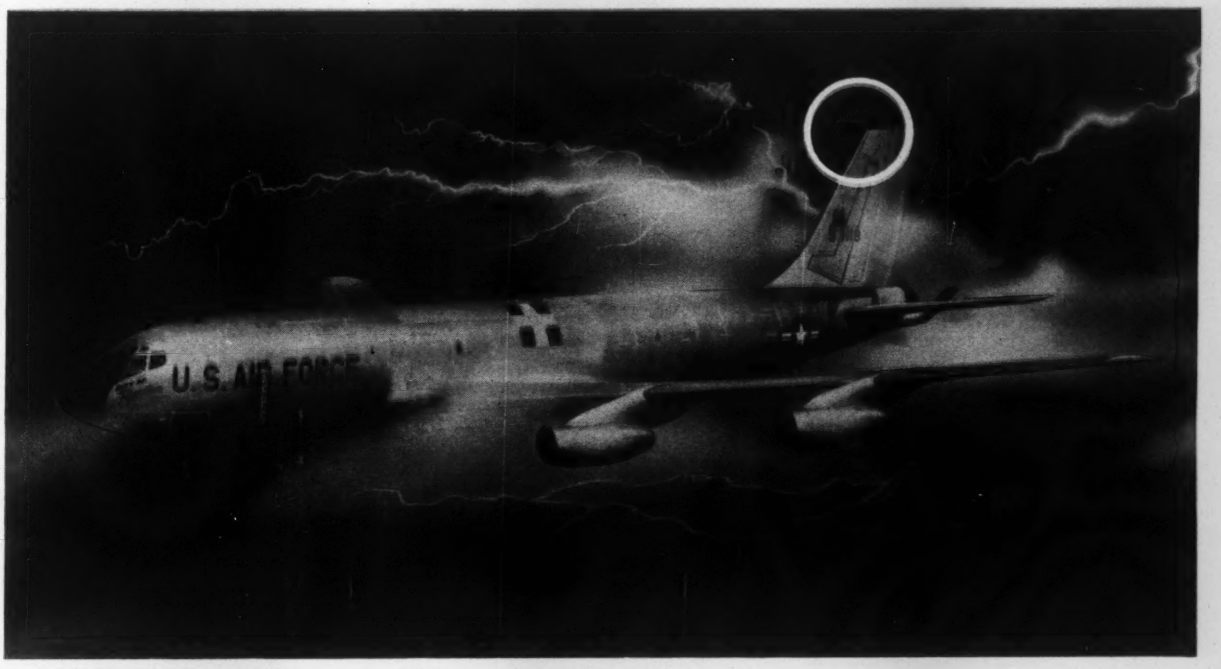
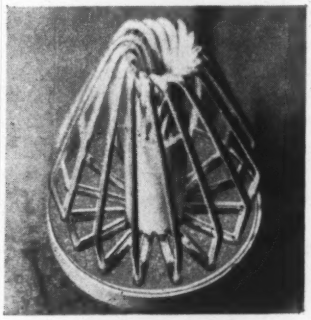
SILICONE NEWS from Dow Corning

Where Weight Counts



Use Silicone Glass Laminates For High Strength, Good Electricals

The combination of exceptional properties and ease of fabrication puts silicone-glass laminates in a class alone. Made with Dow Corning silicone resins, these glass cloth laminates are rigid and strong. Just as important, they offer a better strength-to-weight ratio than many light metals. At −80 F or 750 F (even higher temperatures intermittently), silicone laminates retain their high order of resistance to moisture, weathering, ozone, corrosion, thermal shock, vibration and fungus attack. Dielectric properties stay constant.



LIGHTNING BARRIER. An example of how both the mechanical and dielectric properties of silicone laminates can be used to good advantage is illustrated above. A slotted silicone laminate spring guide is a key component of the lightning arrester on this jet aircraft. The arrester protects the probe antennae of long range HF communication systems from damage by electrical discharge. The slotted laminate serves as both a retainer and an insulator for the flexible spring elements.

HEAT REFLECTORS. Ducts, pods, and shields for missiles and aircraft are also made of silicone-glass laminates. In the Super Sabre F-100 built by North American Aviation, a rigid drag chute case is made with these rugged silicone materials. Positioned next to the engine at the rudder base where continuous heat is 750 F, the gold-metallized case resists jet engine ambients, reflects heat away without loss of structural strength.

TYPICAL PHYSICAL PROPERTIES

Flexural Strength, psi	20-40,000
After 200 hrs at 500 F	10-19,500
Tensile Strength, psi	10-14,000
After 200 hrs at 500 F	14-18,000
Tensile Strength to Weight Ratio	4.7×10^{-2}
After 200 hrs at 500 F	9.3×10^{-2}

For further data and a
list of fabricators of silicone laminates,
write today to Dept. 7421a.

first in silicones

Dow Corning CORPORATION
MIDLAND, MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D. C.

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Designing For Cost Conscious People? Then Read . . .

Lockheed F-104A Starfighter with aluminum surfaces protected by Iridite 14-2.

How IRIDITE® Helps Lockheed Cut Aluminum Finishing Costs

Nine years ago, Lockheed switched from anodizing to Iridite chromate conversion coatings. That year, they saved over $40,000 in materials and manpower.

Today, Lockheed is still saving money with Iridite 14–2. Here's how:

Process time is reduced from 45 minutes to a maximum of only 5 minutes. Three times as much work is processed in a single run. Easy-to-load baskets, replacing costly anodizing racks, save $15,000 per year. Expensive electrical equipment is eliminated because Iridite is a simple chemical dip.

Moreover, Iridite 14–2 gives improved corrosion resistance, easily meeting MIL–C–5541, and provides excellent paint adhesion.

More than likely, Iridite can save you money and give you better finishing results than your present method. Discuss it with your Allied Field Representative. Or, write for literature.

Allied Research Products, Inc. 4004-06 EAST MONUMENT STREET • BALTIMORE 5, MARYLAND
BRANCH PLANT: 400 MIDLAND AVENUE • DETROIT 3, MICHIGAN
West Coast Licensee for Process Chemicals: L. H. Butcher Co. • European Agent: Sture Granberger, Storgatan 10, Stockholm, Sweden

Chemical and Electro chemical Processes, Anodes, Rectifiers, Equipment and Supplies for Metal Finishing

IRIDITE®	IRILAC®	ISOBRITE®	ARP®	WAGNER
Chromates	Coatings	Brighteners	Supplies	Equipment

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ASARCON

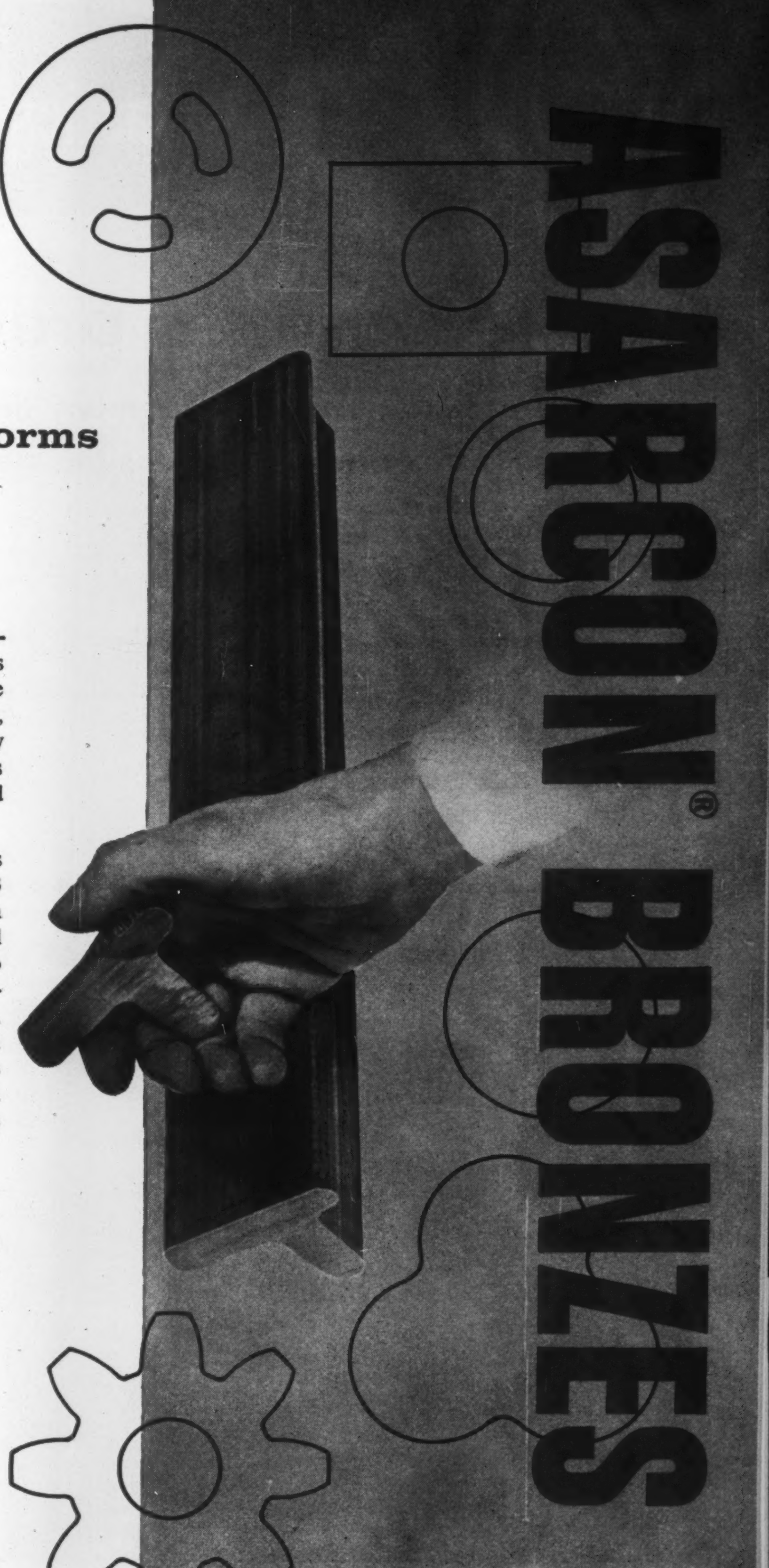
custom shapes and forms in any lengths you need

Asarcon continuous castings give you an extremely wide variety of shapes and forms in standard bronze alloys. They will increase your production rates and lower your costs, because: you get the shape you want in any length you need up to 20 feet. This permits machining on automatic screw machines and other high-speed equipment.

Continuous casting of Asarcon bronzes raises fatigue characteristics of standard alloys 33 to 100%, increases impact strength from 15% to more than double that of identical alloys cast other ways, adds materially to tensile, yield strengths and hardness. Asarcon 773 (SAE 660) bearing bronze in solids, rods and tubes is immediately available from stock in your choice of more than 260 sizes up to 9″ O.D. and lengths up to 105″. A wide variety of other special alloys, shapes and sizes produced to order.

For complete data on Asarcon continuous-cast bronze, write Continuous-Cast Department, American Smelting and Refining Company, Perth Amboy, N. J., Whiting, Ind.; or 120 Broadway, New York 5, N. Y.

ASARCO



For more information, turn to Reader Service card, circle No. 378

HERCULES Plastics Hi-Lites

Pro-fax® proves precisely right

A must plastic for many new uses, Pro-fax always provides the most plastic, too

Because it offers advantages never before available in a thermoplastic, Pro-fax polypropylene has become a "must" for many new uses. But not for exactly the same reasons in every instance. Versatile Pro-fax has many important features unique in its price-property class, and often just a single one of them is ample justification for its usage. Sometimes heat and chemical resistance are the all-important "musts." Again, the economies made possible by the built-in Pro-fax hinge have been foremost in prompting its selection. Its light weight and resilience have on many occasions been prime reasons for specifying Pro-fax.

Whatever the "must," Pro-fax invariably also provides the *most* in a modern construction material. Lightest of all plastics, it yields the most plastic product per pound. Its many innate plus features, in terms of properties, processability and cost, always add up to big value in functionality... merchandising appeal.. and consumer satisfaction.

• •

Pro-fax is in the picture when heat resistance is a "must"

Resistance to heat from the projector light made Pro-fax a "must" for "Duojector." This new magnifier-projector for slides, artwork, photos, coins and stamps has a host of other plus features thanks to Pro-fax: compact, attractively styled, readily portable—since it's made with the lightest of all plastics—Duojector is virtually unbreakable, with a rich, colorful finish that is immune to staining and will withstand both use and abuse.

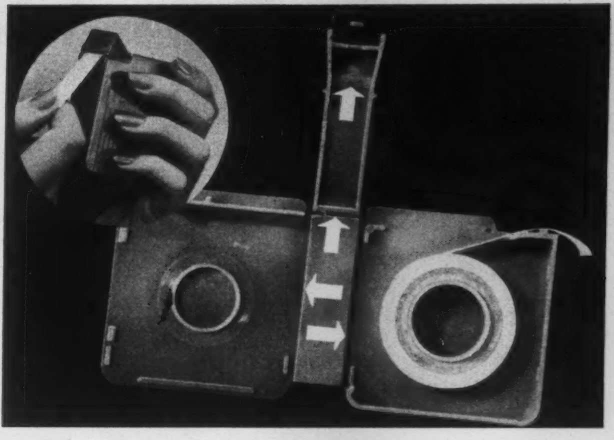
Molded by Como Plastics, Columbus, Indiana, for Rainbow Crafts, Inc., Cincinnati, Ohio.

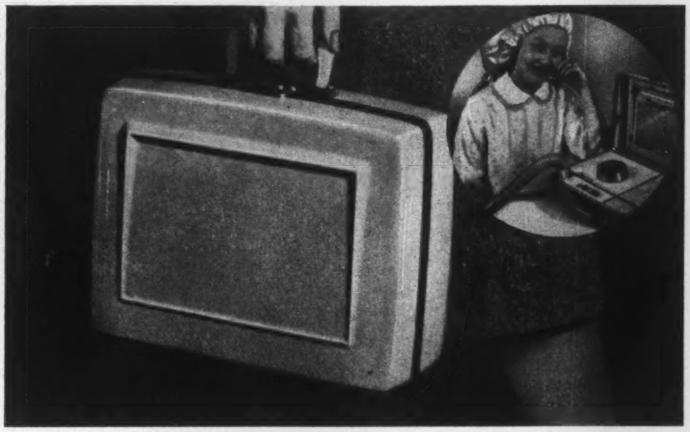
Pro-fax hinges dispense with assembly costs

Pro-fax was a "must" in this unique dispenser-package for Permacel's RIBBON DOPE* Thread Sealant, a new sealer designed for use on threaded pipe joints. Four integrally molded hinges are combined in a single molded part which opens to accommodate a roll of RIBBON DOPE, then folds and locks together to make a lightweight compact carrier. A snap-in blade cuts tape to any desired length, and the handy unit can be tucked in pocket or tool box, stored in any convenient place, or kept available on the worktable. When product success hinges on functionality plus low cost, Pro-fax provides the *most* plastic for the job.

*Trademark of Permacel

Molded by Pyro Plastics Corp., Union, N. J., for Permacel, New Brunswick, N. J.





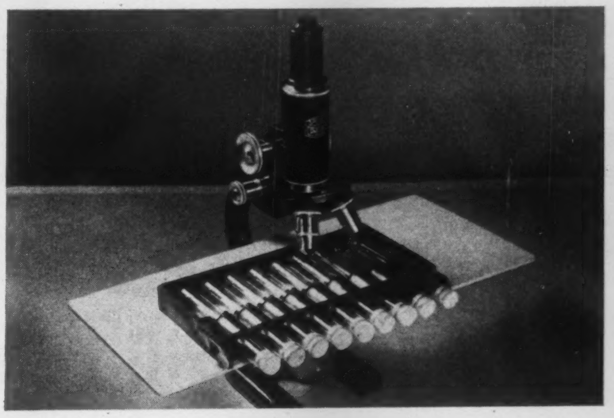
DOMINION makes a case for Pro-fax in portable home appliances

All of the advantages of Pro-fax which make it ideal for luggage—light weight, resilience, resistance to scuffing and staining—were needed in the case for Dominion Electric's new hair dryer. But UL listing was required, too. Dominion achieved this by the use of an intumescent coating, applied to the interior surface of this handsome injection-molded carrier. Result: A revolutionary new appliance, a veritable portable beauty salon, easily moved, usable anywhere.

Molded by Compro Company, Canton, Ohio, for Dominion Electric Corp., Mansfield, Ohio.

Many "musts" make Pro-fax the most

The combination of properties available in Pro-fax made this radical new concept in laboratory equipment a reality. Six of these molded "drawers," each holding nine culture tubes, nest in a compact case which permits handling 54 tubes at one time. They replace a cumbersome metal rack which required individual handling of each tube under the microscope and during subsequent cleaning and sterilizing. Pro-fax was a "must" for the resilient retainer rings which anchor test tubes firmly in place so that a full drawer can be studied, washed, and steam-autoclaved without removal. Pro-fax was a "must," too, for the built-in hinge catch on each drawer, designed to hold it in the six-drawer case. All these many "musts" have made Pro-fax the *most* plastic for a variety of new laboratory-ware applications, including test tubes, beakers, and a number of measuring devices.



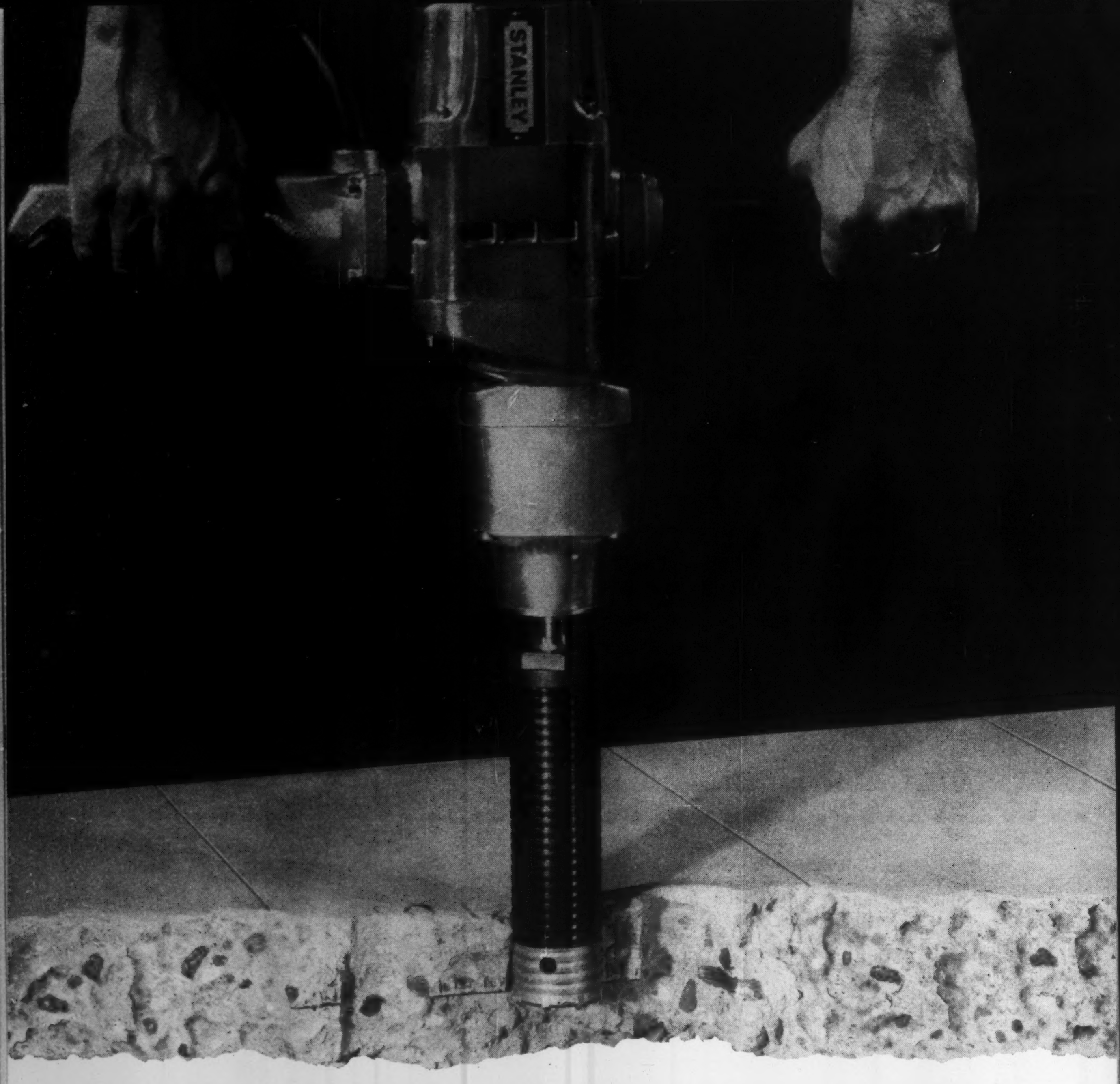
Molded by Philadelphia Plastics and Manufacturing Co., Phila., Pa., for Advance Scientific Corp., Phila., Pa.

HERCULES POWDER COMPANY

Polymers Department
Hercules Tower, 910 Market Street, Wilmington 99, Delaware

QP61-3

For more information, turn to Reader Service card, circle No. 448



Built to drill reinforced concrete

Stanley No. 404 portable drill gets critical strength from gears and pinions of Nickel alloy steel.

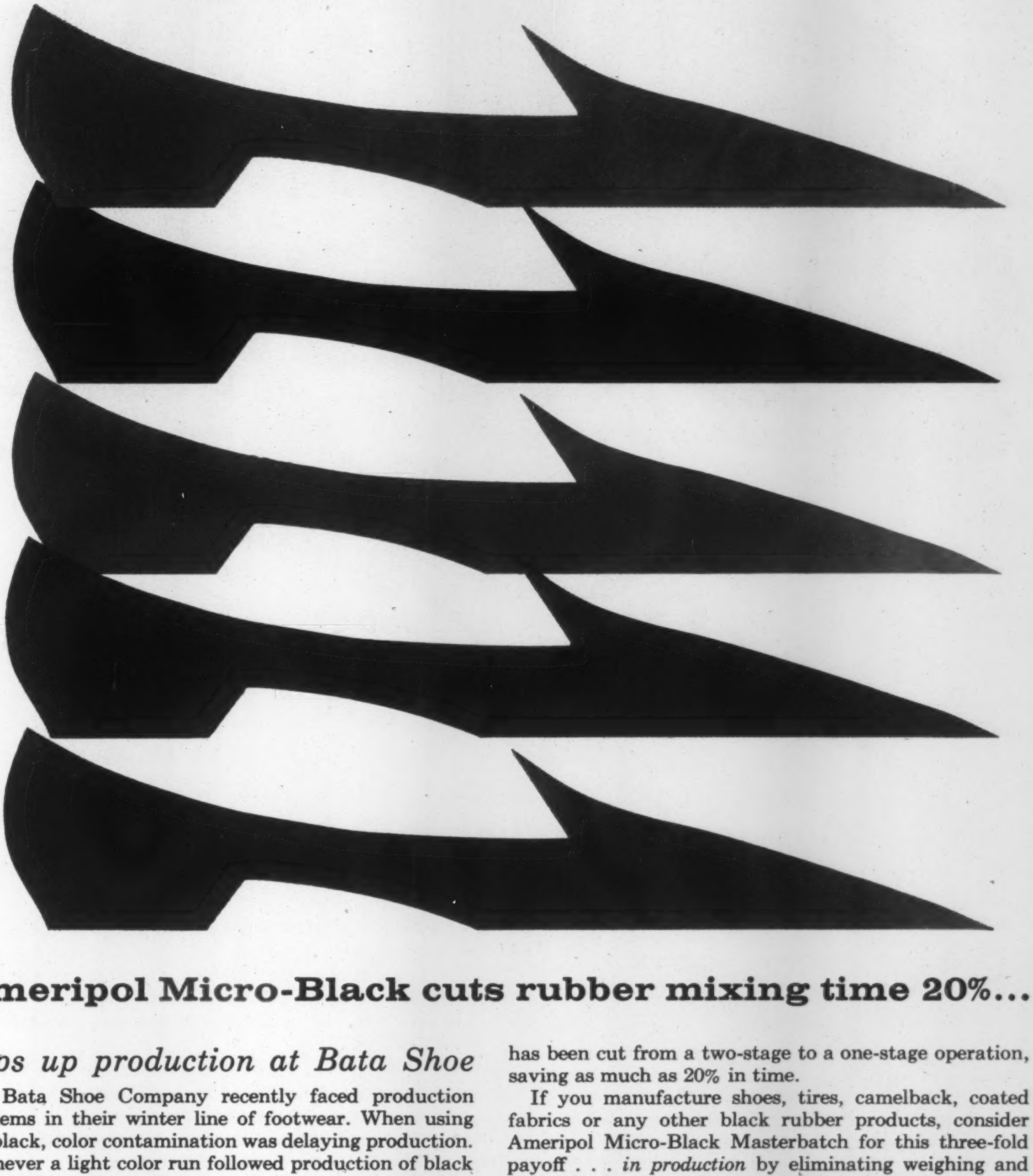
This electrically powered impact drill is designed to cut through reinforced concrete, brick, stone, masonry materials, and concrete pipe . . . *without deflection.* It can drill holes or cut cores in any diameter from $\frac{3}{16}$" to 4" without chipping, cracking or breaking out when close to an edge.

To give this hard-hitting drill built-in stamina, Stanley engineers specify carburized AISI 4620 (1.8% nickel) for critical parts of the power train. The hard case and tough core of this nickel alloy steel stand up to the severe operating shocks of impact drilling . . . provide outstanding resistance to fatigue and wear.

When you design, order, or use heavily stressed machine components, remember that nickel alloy steels take the tough jobs in stride. For helpful engineering data on these alloys write to Inco. We'll be glad to help.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

INCO NICKEL
Nickel makes alloys perform better longer



Ameripol Micro-Black cuts rubber mixing time 20%...

steps up production at Bata Shoe

The Bata Shoe Company recently faced production problems in their winter line of footwear. When using free black, color contamination was delaying production. Whenever a light color run followed production of black items, Bata was forced to close the line while equipment was painstakingly cleaned. It was a time-consuming, messy job.

For Bata, the solution was a changeover to Goodrich-Gulf Ameripol Micro-Black Masterbatch. Using Ameripol 1605, the most delicate pastel shades now follow black with no contamination problems. And, equipment, employees and production lines *stay* clean. Mixing time has been cut from a two-stage to a one-stage operation, saving as much as 20% in time.

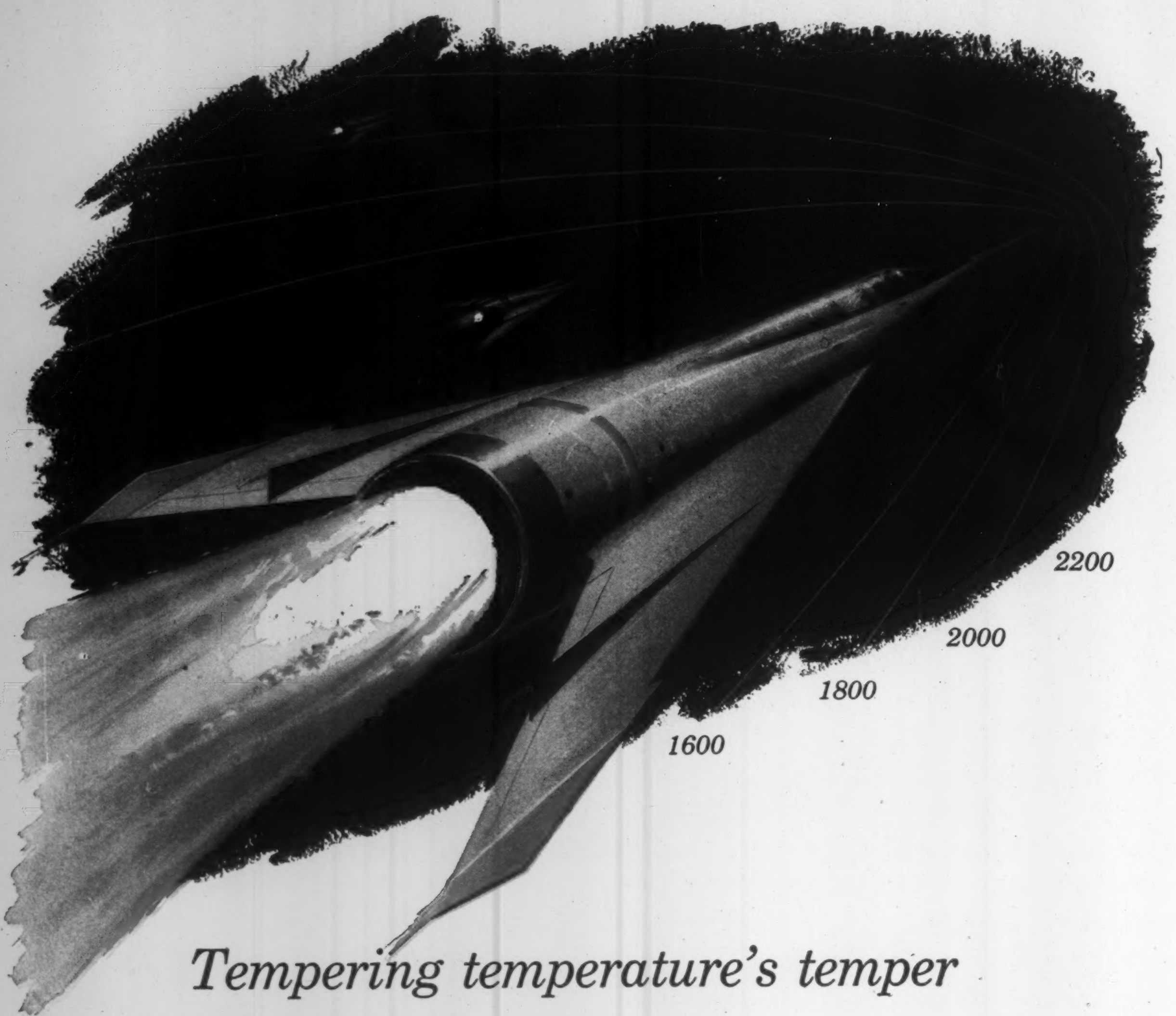
If you manufacture shoes, tires, camelback, coated fabrics or any other black rubber products, consider Ameripol Micro-Black Masterbatch for this three-fold payoff . . . *in production* by eliminating weighing and milling operations plus shortening mixing time . . . *in storage* by eliminating in-plant handling of carbon black . . . *in products* by assuring thorough dispersion of carbon black in the rubber for increased abrasion resistance, lower heat build-up.

Put Micro-Black to work on your production line. Call your Goodrich-Gulf sales engineer. Or write us at 1717 East Ninth Street, Cleveland 14, Ohio.

Goodrich-Gulf Chemicals, Inc.

WORLD'S LARGEST SOURCE OF SYNTHETIC RUBBER

For more information, turn to Reader Service card circle No. 473

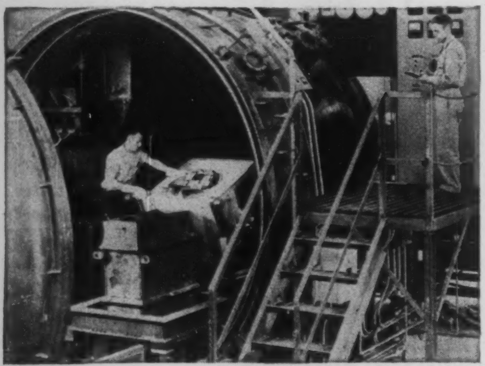


Tempering temperature's temper

Heat of 2000+ deg. F. is generated in a supersonic jet's tailpipe. So is extreme vibration.

By far the best alloy tested for this critical component is MULTIMET alloy—one of 12 HAYNES alloys helping combat heat, stress, and erosion in the jet engine, missile, and rocket field.

HAYNES alloys are relied on for use in afterburners, turbine blades, nozzle vanes, and many other high-temperature parts. All 12 HAYNES high-temperature alloys are *production* alloys and are readily available. Some are vacuum melted. Some air melted. Some are cast, some wrought, some are produced in both forms.



Complete vacuum melting equipment is part of HAYNES STELLITE's modern plant facilities. For full details, write for 48-page descriptive booklet.

HAYNES
ALLOYS
HAYNES STELLITE COMPANY
Division of Union Carbide Corporation
Kokomo, Indiana

UNION CARBIDE

Address inquiries to Haynes Stellite Company, 270 Park Avenue, New York 17, N. Y.

"Haynes," "Multimet," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

For more information, turn to Reader Service card, circle No. 390

SANDVIK 11R51 STAINLESS STEEL

A Proven Solution To These Spring Problems

Sandvik 11R51 steels' combination of high corrosion resistance and superior spring characteristics has proven itself in spring designs which must . . . .

1 Withstand severe temperature changes and condensates
2 Have high fatigue life and tensile strength
3 Provide high torque values
4 Not creep during long period of stress
5 Give consistent, predictable results

To learn more about how this special steel can solve your specific spring design problems, eliminate the need for redesign and retooling, and improve your product, *use this coupon.*

SANDVIK STEEL, INC.
1702 NEVINS RD., FAIRLAWN, N. J.

☐ Please send me your free booklet on Sandvik 11R51.
☐ Please have your representative phone for an appointment.

Name____________________ Title__________
Company____________________________
Address____________________________

SANDVIK STEEL INC.
1702 Nevins Road, Fairlawn, N. J.
Tel. SWarthmore 7-6200
In N.Y.C. ALgonquin 5-2200
Branch Offices: Cleveland • Detroit • Skokie
Los Angeles

SANDVIK CANADIAN LTD., P. O. Drawer 1335, Sta. O, Montreal 9, P. Q.
Works: Sandviken, Sweden.

SS-226

For more information, turn to Reader Service card, circle No. 388

STOKES invites you to investigate the many marketing advantages of offering your product in tablet form. By the simple device of tabletting your product in a distinctive shape, for example, you can establish strong product identity . . . even in a highly competitive market. Since tablets are more compact than powders, package-size requirements are reduced. The savings realized from this reduction in size can be put to work "glamorizing" the package.

Tablets also have the advantage of built-in measurement. With a tablet detergent, for example, busy housewives do not have to waste time fumbling with measuring cups. A few tablets and the family wash is ready to go. Kiddies can also make their own soft drinks with a single, no-mess effervescent tablet.

And this is just a sampling of the many exciting marketing possibilities offered by modern high-speed tabletting. There are many production advantages, too. To get more information, contact your nearest Stokes representative. If you desire, we will gladly test run your product in the Stokes Laboratory and make detailed tabletting recommendations. Tabletting Press Division, F. J. Stokes Corporation, 5500 Tabor Road, Philadelphia 20, Pennsylvania.

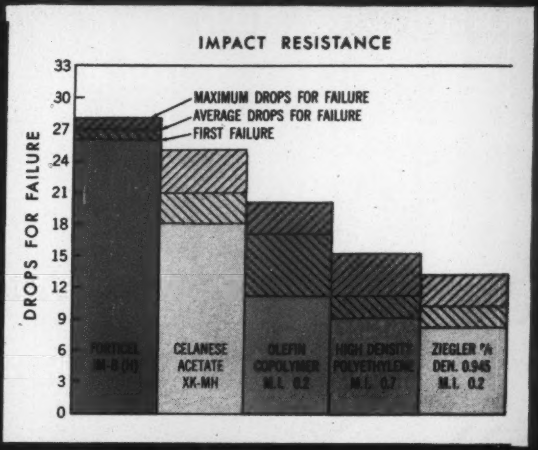
detergents
soft drinks
coffee
bleach
bath salts
insecticides
water treatment tablets
concentrated foods
tea
salt
spices
candies

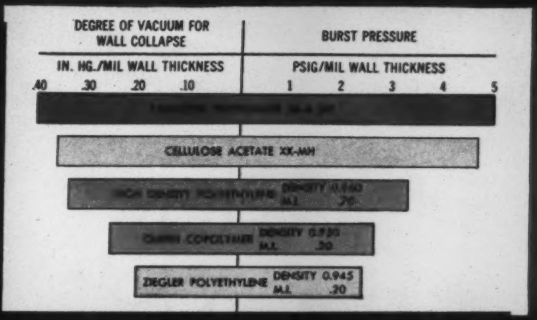
think tablets

Put **STOKES** 50 years of tabletting experience to work for YOU!

For more information, turn to Reader Service card, circle No. 445

CELANESE POLYMER COMPANY





In blow-molding . . .

Only Cellulosics offer toughness and transparency with economy

New blow molding techniques, new cellulosic materials can mean improved products and lower costs for you. And you can depend on Celanese for the newest and best in cellulosics!

Bottles, for example, blow-molded of Celanese cellulosics are light in weight . . . economical . . . far stronger and impact-resistant than similar bottles of many polyethylenes. And they will hold many products polyethylene can't. Proof? Refer to the charts on this page. And specific formulations can be had with either FDA or Underwriters approval.

Celanese Forticel and Celanese Acetate are two cellulosics well worth your interest. Both are high impact, rigid, shatter-resistant plastics. They offer fine surface, color permanence—come in transparent or opaque formulations. Acetate is the mature, proved plastic while Forticel has the best *combination* of properties of all the cellulosics.

Don't *you* overlook the tried and true advantages of cellulosics—for various uses from bottles to industrial components. Only cellulosics offer you both toughness and transparency at a reasonable price.

Celanese® Forticel®

CLIP THE COUPON FOR DATA ON CELLULOSICS!

Celanese Polymer Company, Dept. P102S
744 Broad Street, Newark 2, N. J.
Please send me bulletin A3-B "Blow-molding Cellulosics"

NAME________________________________

COMPANY________________________________

ADDRESS________________________________

CITY____________________ZONE______STATE______

Celanese POLYMER

Celanese Polymer Company is a Division of Celanese Corporation of America
Canadian Affiliate: Canadian Chemical Company Limited, Montreal, Toronto, Vancouver
Export Sales: Amcel Co., and Amcel Co., Inc., 522 Fifth Avenue, New York 36.

For more information, circle No. 389

Another vital new
concept in chemical
pre-paint treatment
by AMCHEM!
ROLL
COAT
APPLICATION
OF
ALODINE*
FOR
PRE-TREATING
ALUMINUM!

Now, Amchem further widens pre-paint treatment flexibility! First there was spray application, then dip, then spray-dip—all exclusive Amchem developments. And today, Amchem announces *roll coat application* of chromate coatings, providing still more features and economies in treating aluminum!

Roll coating with Alodine offers greater flexibility in processing and in speed, in cost reductions for maintenance. Equipment required is minimized. Uniformity of coating is equal to or better than existing methods. Advanced equipment design and increased chemical activity of Alodine 1200 Series chemicals make roll coating possible. It is the most practical and efficient pre-treating process yet available for aluminum fabricators.

Get the full details on how roll coating with Alodine can save you substantial time, money and labor while boosting product quality through the ultimate in paint adhesion. Call your local Amchem Representative, or write us direct, but do it soon!

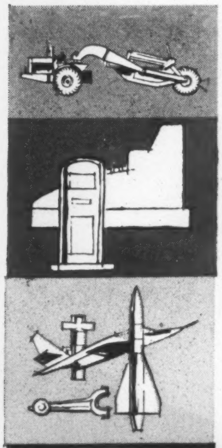
*Amchem's registered trademark for its conversion-coating chemicals for aluminum.

AMCHEM ALODINE

Amchem is a registered trademark of
AMCHEM PRODUCTS, INC. (Formerly American Chemical Paint Co.)
AMBLER, PA. • St. Joseph, Mo. • Detroit, Mich. • Niles, Calif. • Windsor, Ont.

For more information, turn to Reader Service card, circle No. 394

apply the
T & W TECHNIQUE
to reduce cost . . . improve quality



T & W was able to save one manufacturer 54% on the total overall cost of his part. This and many more such examples are the end result of T & W applying a modern concept of ideas and experience which is helping manufacturers in a wide range of industries to *reduce parts cost and improve quality.*

Let T & W try to do the same for you. *Just call or write—or send us a print.*

in forgings

Sizes: 1 ounce to 500 pounds.

Materials: Carbon and Alloy Steel, Non Ferrous and Stainless, Titanium, Pure Molybdenum, and High Temperature Alloys (Plain or Heat Treated).

IT'S BETTER FORGED

in stampings

Sizes: 3 inches by 3 inches, to 60 inches long, 40 inches wide and 16 inches in drawn depth.

Materials: Steel, Stainless and Aluminum. (Blanking, forming, welding, sub and final assemblies).

ALLIANCE, OHIO

TRANSUE & WILLIAMS

COMMERCIAL FORGINGS AND DEEP DRAWN STAMPINGS

Sales Offices: Philadelphia • Chicago • Dallas
Old Saybrook (Conn.) • Detroit • Los Angeles

For more information, turn to Reader Service card, circle No. 340

A Look in a New Direction

There are so many things epoxy resins do *and do well.* There must be many more. ☆ The promise of this is everywhere. What these remarkable resins already have contributed to fresh ideas in practical product development we believe is only a beginning. The range of epoxy resin potential in your business, for example, may well be limited only by the opportunity to show what can be done. ☆ You are likely to find in the abundance of properties uniquely combined in the epoxies a material answer to a basic problem in design, production, or both. ☆ CIBA has pioneered continuously in epoxy resins development since their introduction. CIBA basic research and collaborative investigations continue to carry this work forward with formulators and end-users. This sound integration of effort, along with a strong basic raw material position and the most modern production facilities of their kind, is enabling us to help point the way to many new fields of application. ☆ For all who are interested, the first step is to know as much as possible about what epoxy resins are and do. CIBA, *where research is the tradition,* we believe can help you to take a stimulating look in a new direction.

CIBA Products Corporation, Fair Lawn, N. J.

Innovations in strength and beauty for the new architecture . . . safety surfacing and minimum maintenance to cope with modern highway traffic wear and tear . . . power-packed heat-shielding protection for delicate electronic elements and structural components in guided missiles . . . adhesives for industry and the household that are unmatched for strength and permanence in new assembly and repair . . . are a few of the many forward steps CIBA Araldite® Epoxy Resins have achieved.

CIBA
First in Epoxies

CIBA

For more information, circle No. 433

TEMPERATURE EXTREMES CREATE A DESIGN PROBLEM?

Du Pont coated fabrics made with silicones may help you solve it

Du Pont Fairprene® fabrics coated with silicones (polysiloxane polymers) offer a wide range of application possibilities in product design and improvement. Note these outstanding properties:

- They remain flexible even in sub-zero temperatures down to –65°F. . . . yet resist temperatures as high as 450°F.
- They resist oxidation, ozone, and corona . . . properties that add to their value in the electrical insulating field.
- Exceptional anti-stick qualities.
- Excellent electrical resistance and a dielectric strength of 500 VPM or better.
- Silicone rubber sheets are also ideal for gasketing materials in high- and low-temperature applications.
- They're strong and flexible.
- Resist oil and abrasion.
- Du Pont "Fairprene"-coated fabrics offer almost unlimited properties to help solve design problems. Fabrics of "Dacron"*, "Teflon"**, glass and other substrates are available with elastomeric coatings 38" wide and in thicknesses ranging from 1/64" to 1/8".

If you have a design problem, send coupon below for technical literature and samples of these fabrics. Du Pont has had wide experience in the development of coated fabrics for many applications, and stands ready to work with manufacturers in formulating coated fabrics or sheet stocks to meet specific requirements.

*"Dacron" is Du Pont's registered trademark for its polyester fiber.
**"Teflon" is Du Pont's registered trademark for its tetrafluoroethylene.

E. I. du Pont de Nemours & Co. (Inc.)
Fabric Trade Products, Dept. **MD 1-9**
Wilmington 98, Delaware

Please send literature on "Fairprene" fabrics coated with silicones.

Name____________________

Position____________________

Company____________________

Address____________________

City__________ Zone______ State________

INDUSTRIAL COATED FABRICS

DU PONT
REG. U. S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING . . . *THROUGH CHEMISTRY*

For more information, turn to Reader Service card, circle No. 334

TO INSURE SUCCESSFUL PERFORMANCE EVERY GRAMIX® PART IS

(PRODUCTS OF POWDER METALLURGY)

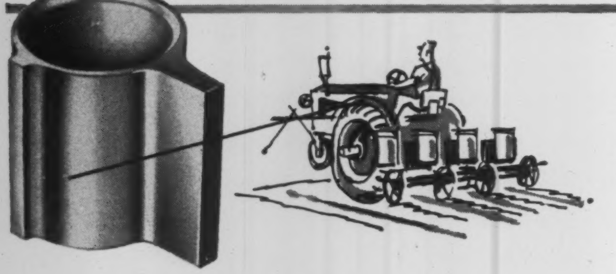
APPLICATION ENGINEERED

One of the most important factors to consider when purchasing powder metal parts is that of successful part performance; for a part to successfully perform its job, all of its physical and metallurgical characteristics must be suited to the application.

GRAMIX Products of Powder Metallurgy are always *Application Engineered,* which means product is specially matched to each specific application. From an almost unlimited variety of metal mixtures, one alloy is blended that contains the required properties and characteristics of the finished part; *all* aspects of part design and conditions under which it must operate are taken into account. Only then is the GRAMIX part produced.

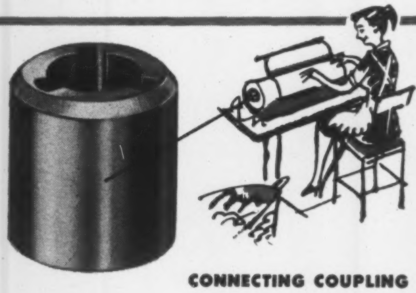
Eight of these *Application Engineered* GRAMIX parts are shown here. Each precisely suits the requirements of its job . . . each is the best part available for the job.

When you specify a GRAMIX part, you can always be sure that it has been *Application Engineered* for successful performance, long life and complete reliability. For more information on *Application Engineered* GRAMIX parts, write for Engineering Handbook G-55.



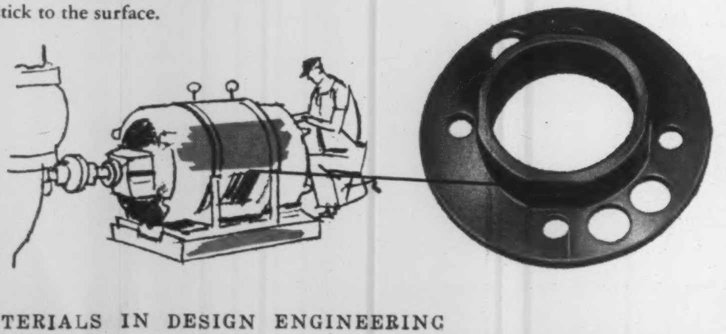
CORN SEEDER

GRAMIX was the material specified for this corn seeder part because the surface finish obtainable with the alloy used reduced the tendency of material to stick to the surface.



CONNECTING COUPLING

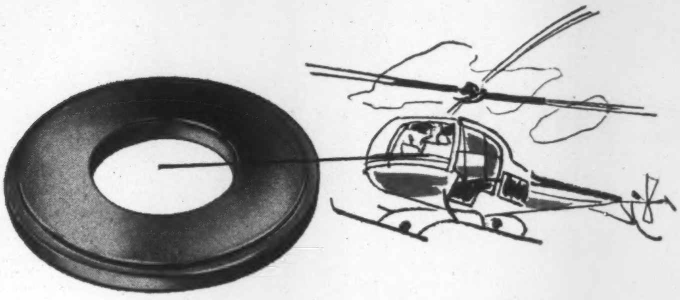
The connecting coupling employed in a small home ironer is formed from a special GRAMIX hardened steel alloy; it offers low wear and shock resistance.



CONTAINER COVER END CAP

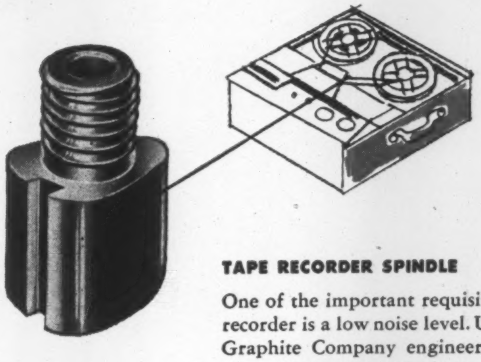
Great savings were realized when retainer caps for certain types of electric motors were made of GRAMIX.

This process made it simple and economical to mold the multiple holes to precise tolerances without extra operations.



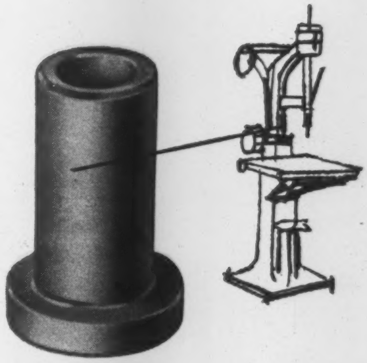
HELICOPTER THRUST WASHER

The outstanding features of the GRAMIX alloy specified for this thrust washer are a dependable and consistent friction and wear pattern as well as a fine surface finish.



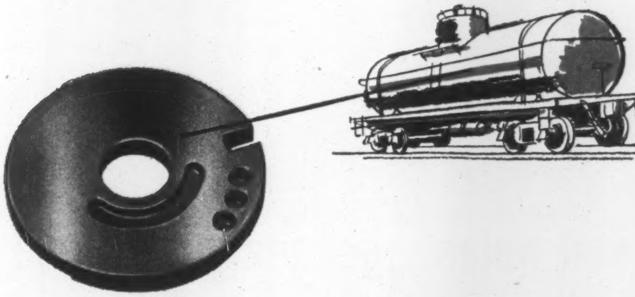
TAPE RECORDER SPINDLE

One of the important requisites in a tape recorder is a low noise level. United States Graphite Company engineers developed a special alloy to meet these requirements in the GRAMIX spindle.



GUIDE BEARING

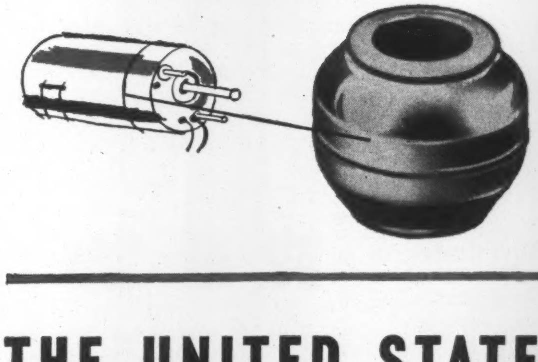
Built-in lubrication and low friction to reduce heat are important features of the GRAMIX alloy chosen for this guide bearing.



LIQUID PUMP END PLATE

This end plate is typical of many parts employed in liquid pumps of many types.

It is made from a wear resistant bronze alloy that was developed for pump applications.



FRACTIONAL H.P. MOTOR

The GRAMIX bearing for this Fractional h.p. motor was developed from a special low noise level alloy.

Its self-lubricating properties were also an important consideration in specifying GRAMIX.

METAL POWDER
mpi
INDUSTRIES FEDERATION

X-296-2

THE UNITED STATES GRAPHITE COMPANY

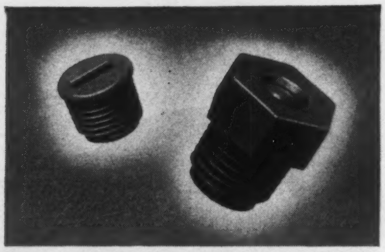
DIVISION OF THE WICKES CORPORATION, SAGINAW 3, MICHIGAN

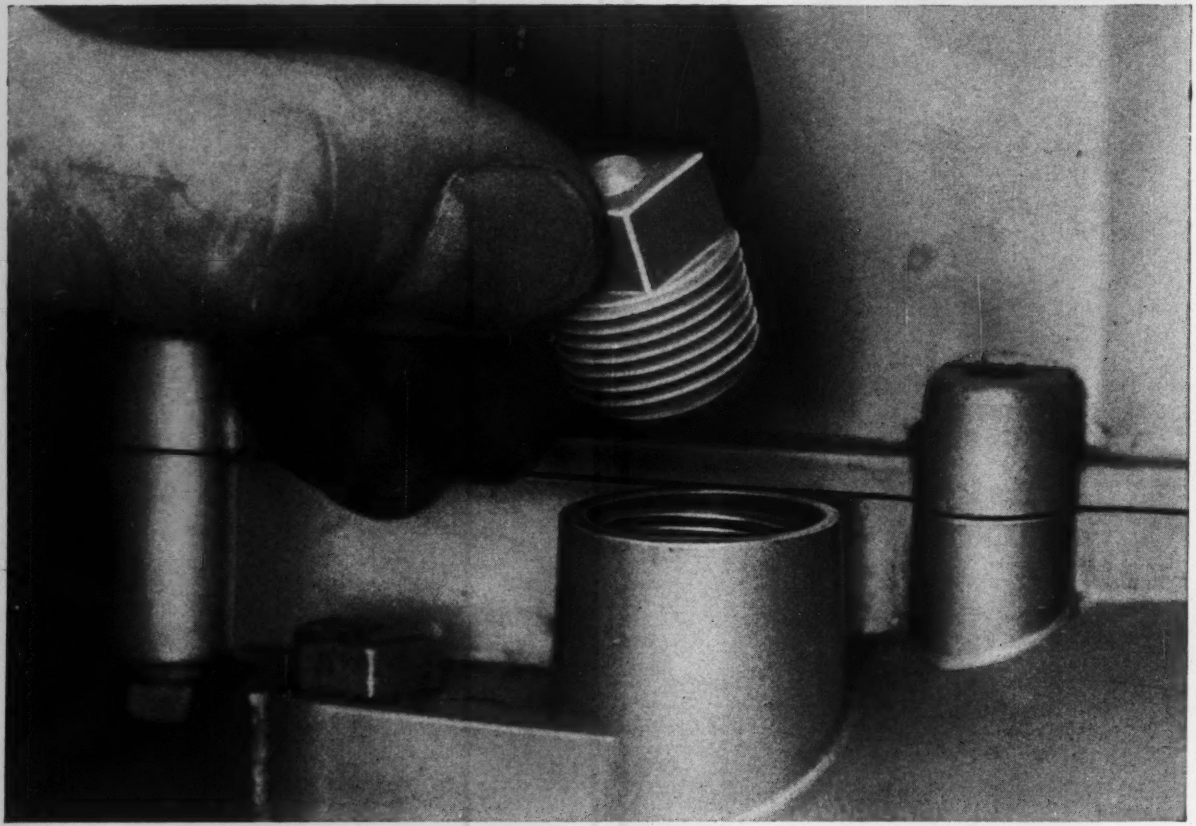
GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

For more information, turn to Reader Service card, circle No. 402

New, complete line of

RB&W molded plugs





Avoid damage to threaded holes...get leakproof seal, too

You entirely eliminate the risk of damaging a costly tapped hole with RB&W molded plugs. If inadvertently crossed-threaded, their plastic material yields to metal threads—especially important where the tapped holes are in malleable metals.

They seal tightly under pressure, too. That's because all RB&W plastic plugs are molded hollow. Fluids under pressure exert radial forces that expand threads for an even tighter, dry, plastic-to-metal contact.

They resist corrosion, usually cost less than their metal counterparts, are available in various materials for various jobs.

DELRIN®—All-purpose RB&W Delrin® plugs ideally seal gases or fluids in compressors, pumps, valves, pneumatic and hydraulic systems, or any service involving contact with petroleum derivatives. Delrin plugs have metal-like mechanical properties, are suitable for use to 250°F.

NYLON—Made from *heat-stabilized* nylon (Zytel® 103), RB&W plugs withstand temperatures exceeding 300°F, remain leakproof at working pressures to 3000 psi.

NYLON—Made from *hydrolysis-resistant* nylon, (Zytel® 2281), RB&W plugs assure dependable service when continuously exposed to hot water or vapor.

POLYETHYLENE—RB&W polyethylene plugs, in two head styles, economically seal threaded openings to exclude dirt, contaminants, and moisture during shipping or handling. They can be tightened with fingers or wrench.

Send for data sheet which gives sizes and other specifications. Write Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, N. Y.

® *du Pont trademark*

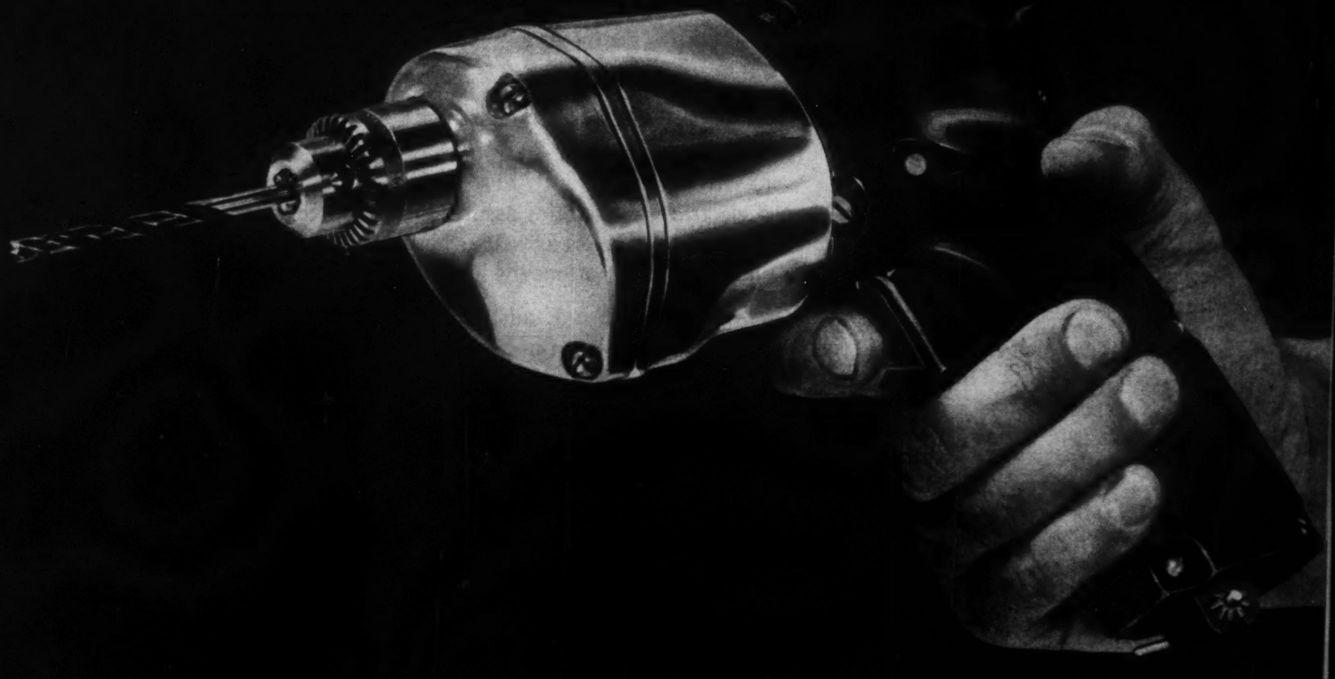
RB&W
117th year

Plants at: Port Chester, N. Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. **Additional sales offices at:** Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

▲ For more information, turn to Reader Service card, circle No. 416

For more information, circle No. 484 ➤

TEAMWORK BEATS SCHEDULE IN MARKETING FIRST CORDLESS DRILL



DIES DESIGNED AND CASTINGS DELIVERED IN THREE WEEKS BY DOEHLER-JARVIS!

A 'breakthrough' product means a race against time. Get it in production and on the market while it is still "hot" news.

That was the situation Black and Decker faced in developing the first "cordless" electric drill.

A major time factor—the design and construction of dies and the die casting of three major elements of the revolutionary new product.

The question put to Doehler-Jarvis—can you design and build the dies and deliver aluminum castings for the gear case, gear case cover and field case in three weeks?

The answer—we did it!

The first delivery of completed castings was made in three days less than three weeks.

This is *not* a routine situation. But it is an outstanding example of how Doehler-Jarvis' 57 years of leadership in die casting can work to your benefit in all circumstances. It was the design and engineering skill and experience of Doehler-Jarvis, together with their unmatched production facilities and know-how which helped Black and Decker meet its ultra-tight production schedule.

But there was more to gain than speed. The die cast parts delivered to Black and Decker have the high strength, impact resistance and abrasion resistance needed to take rough handling; they are sound and dimensionally stable to permit and maintain close tolerance; and their attractive finish adds extra sales value.

You will find it to your advantage to talk to Doehler-Jarvis about die castings for your products. Contact the office nearest you.

DJ DOEHLER-JARVIS Doehler-Jarvis

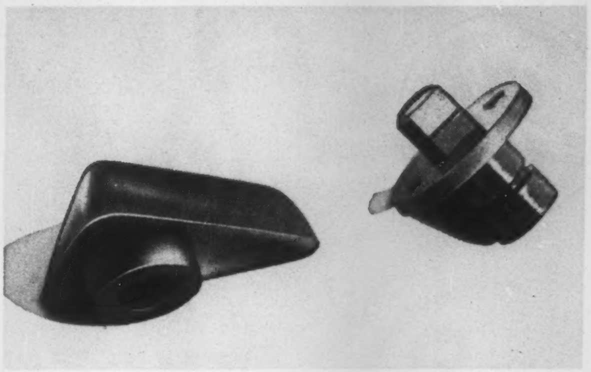
Division of National Lead Company • General Offices: Toledo 1, Ohio
Plants and Sales Offices: Toledo, Ohio; Grand Rapids, Michigan; Pottstown, Pennsylvania; Batavia, New York.
In Canada: Barber Die Casting Co., Ltd., Hamilton, Ontario.
In Brazil: Industrias Doehler do Brasil, S. A., Sao Bernardo do Campo, Sao Paulo.
In Argentina: Doehler Argentina, S. A., Buenos Aires.
In Great Britain: Metal Castings-Doehler, Ltd., Worcester, England.

SYLVANIA SHAVES COSTS FOR SCHICK-IN PLASTICS, METALS AND ASSEMBLIES

Producing the switch for a compact, 3-speed electric razor leaves almost no margin for error. It must be precisely built and still withstand the punishing abuse of day-to-day handling.

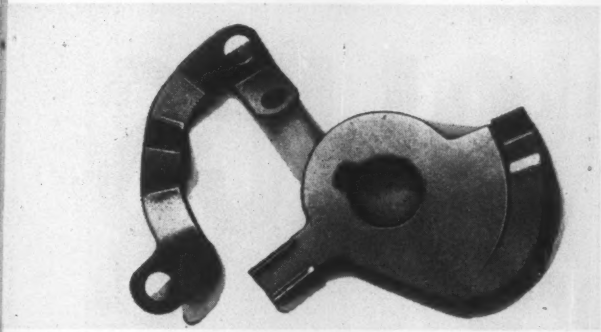
In making the switch for the new Schick razor shown below, Sylvania Parts Division meets these requirements. Our experience with a wide range of materials resulted in better electrical contacts. And our facilities assure durable, precision parts and assemblies as well as high-speed production. The combination means important economies to Schick.

For details, see captions at the right. For full information on how Sylvania custom parts facilities can benefit *you*, or for a quote on a specific project you have in mind, write Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania.



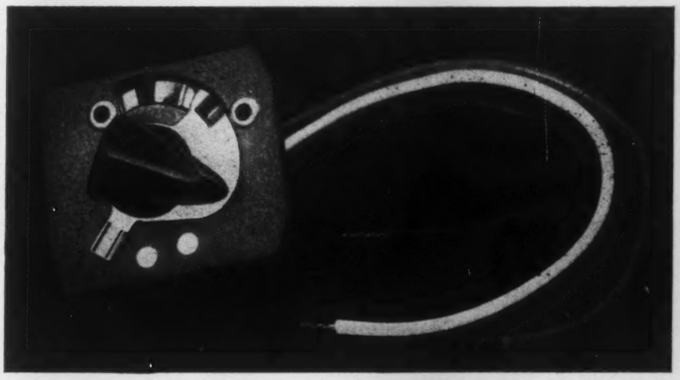
MOLDED FROM PLASTIC are parts for the switch assembly. Each must meet the tightest specifications. Example: Sylvania molds shaft and selector button from nylon, holds dimensions on both to a height and diameter of ±.0015". In addition, the flash is controlled to 1/32" because the button is a snap fit on the shaft. Since Sylvania maintains one of the world's most modern and complete lines of automatic molding equipment, it can handle volume orders for compression, injection and transfer molding. And a unique bank of rotary presses can produce millions of precision parts each day—even using phenolics and urea.

Result to Schick? Precisely molded parts—in volume!



CUSTOM METAL STAMPINGS also proved important to Schick. Sylvania recommended changing the selector detent and rotor to brass, thus permitting a reduction in thickness from .015" to .010" and assuring an improvement in contact from rotor arm to detent. Sylvania made the dies necessary to produce these parts. The Sylvania metal stamping facility includes multi-slide machines, vertical presses and specially developed machines to help solve your problems.

Result to Schick? Positive electrical contacts assured while a 5° offset on the selector rotor is maintained to within ±1° day in and day out.



CUSTOM ASSEMBLY by Sylvania of the switch assembly is handled by our corps of trained specialists. Many of our customers have found that Sylvania can often deliver completely assembled and packaged products—using either all Sylvania components or a combination of some Sylvania and some customer supplied—*at lower cost than is possible in the customer's own facilities.*

Result to Schick? Thousands of completed, durable and precision assemblies per month.

NEED CUSTOM WELDING OR WIRE? Sylvania supplies both. To help you meet your welding needs, Sylvania has developed new high-speed, high-volume techniques and advanced welding equipment—automatic and semiautomatic. To help you with wire, only Sylvania of all major manufacturers makes all three types of bare wire — alloy, clad and plated. They're available in a full range of sizes, too—.002" to .250". Where necessary, Sylvania will precision-roll wire into ribbon connectors that offer high reliability when the circuitry calls for wire wrap contact methods.

SYLVANIA

SUBSIDIARY OF

GENERAL TELEPHONE & ELECTRONICS

GENERAL SYSTEM

For more information, turn to Reader Service card, circle No. 441

THREE NEW PHENOLICS FROM GENERAL ELECTRIC

G-E 12985 **This new General Electric compound is the very finest *heat-resistant* phenolic available in its cost range.**

12985 retains high flex strength after severe heat aging. It has a rich, black color which it maintains well on exposure to heat. The material has a drop impact strength higher than its best competitor . . . equivalent *for the first time* to a general-purpose compound. 12985 takes a hot, speedy preheat and cures rapidly. It has excellent machining properties, good chemical resistance, relatively low specific gravity (1.58). And—it is offered at an attractive price.

SUGGESTED USES: This superb high-temperature material is particularly recommended for handles on skillets and cutlery, for appliance parts, switch and lamp parts, knobs, wiring devices, miniature parts for use at high ambient temperatures.

G-E 12941 **A new concept in general-purpose phenolics: a fast-curing, ammonia-free, non-bleeding black compound.**

This material gives an extremely fast, blister-free, cold-powder cure. There is no danger of staining the mold or tarnishing costly silver contacts. Nor is there any need to worry about high scrap losses caused by uneven flow. Parts produced from 12941 will not bleed.

SUGGESTED USES: Ideal for small, automatically molded parts of all kinds: switch parts, contacts for wire connectors, closures, tube sockets, appliance control parts.

G-E 12942 **This new variant of a popular general-purpose compound offers added impact strength, improved finish and cure.**

A versatile and easily molded compound, 12942 pre-forms well, takes a hot preheat, and flows smoothly in the mold. Parts made of the new compound are smooth, rigid, deep-black, and will not embrittle during tumble finishing. It can be used in cold powder automatic molding with just a slight penalty in cure speed. It is not hand staining.

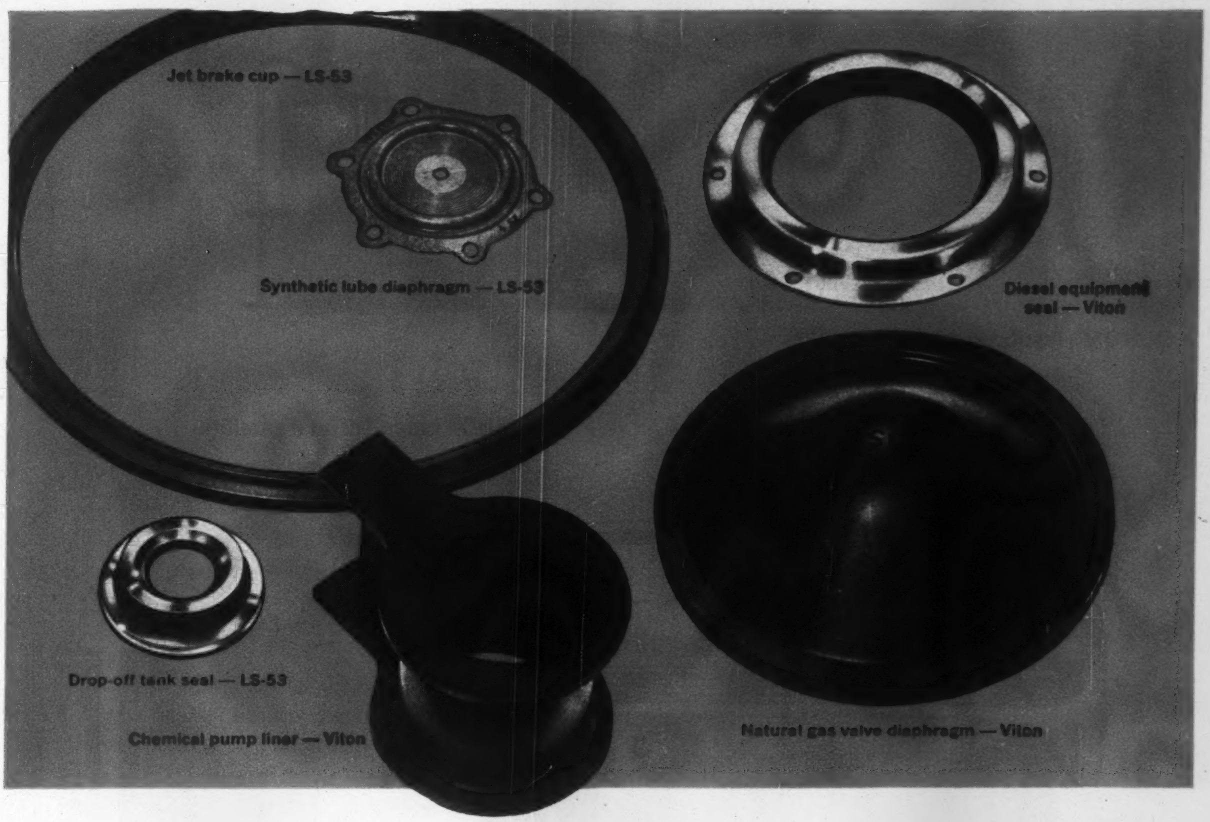
SUGGESTED USES: General applications such as handles, knobs, meter case covers, coffee maker bases, piano sharps.

These three new compounds may well give you an important advantage in processing or properties. General Electric offers you dozens of standardized phenolic compounds, including general purpose, heat resistant, shock resistant, and fast cure phenolics. Our Technical Service people will be glad to help you select the right material for your job. For more information, write to: General Electric Company, Section M-561, Chemical Materials Department, Pittsfield, Mass.

Phenolics-first of the modern plastics...first in value

GENERAL ELECTRIC

For more information, turn to Reader Service card, circle No. 479


Jet brake cup — LS-53
Synthetic lube diaphragm — LS-53
Diesel equipment seal — Viton
Drop-off tank seal — LS-53
Chemical pump liner — Viton
Natural gas valve diaphragm — Viton

For advanced fuel...hydraulic...lube systems,

New materials prove ideal in handling temperature extremes −350° F. to +750° F.

Working with two remarkably versatile elastomers, C/R Sirvene engineers are producing flexible molded parts for many vital fuel, lubricating, hydraulic and pneumatic systems. One, Viton-A*, can be compounded to produce parts that function dependably at 600° F., and for short periods up to 750° F. The other important feature of Viton compounds is their excellent resistance to corrosive chemicals, chlorinated solvents as well as both synthetic and petroleum base fuels and lubes. At the other extreme, C/R compounded Silastic LS-53** parts are providing low temperature operation down to -80° F. They also exhibit excellent resistance to synthetic and petroleum base fluids up to 350° F., and function well in propane up to 500° F. For temperatures as low as -350° F., C/R recommends Teflon* compounds.

C/R Sirvene engineers have an intimate knowledge of these elastomers. They also have perfected special techniques in processing which still further improve the physical properties of the molded parts. If your problem involves high or low temperatures, close tolerances, and compatibility in advanced design fuel, lubricant or hydraulic systems, get in touch with us at once. We have the skill and the facilities to help you.

* DuPont registered trademark
**Dow-Corning registered trademark

CHICAGO RAWHIDE MANUFACTURING COMPANY

C/R

SIRVENE DIVISION, 1227 ELSTON AVENUE • CHICAGO 22, ILLINOIS
Offices in 55 principal cities. See your telephone book.
In Canada: Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario
Export Sales: Geon International Corp., Great Neck, New York
C/R PRODUCTS: **C/R Shaft & End Face Seals • Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic gears**

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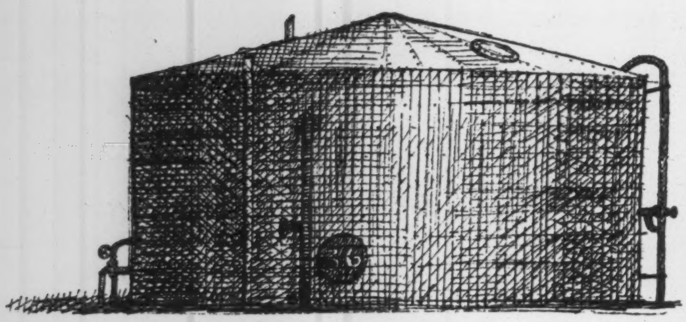
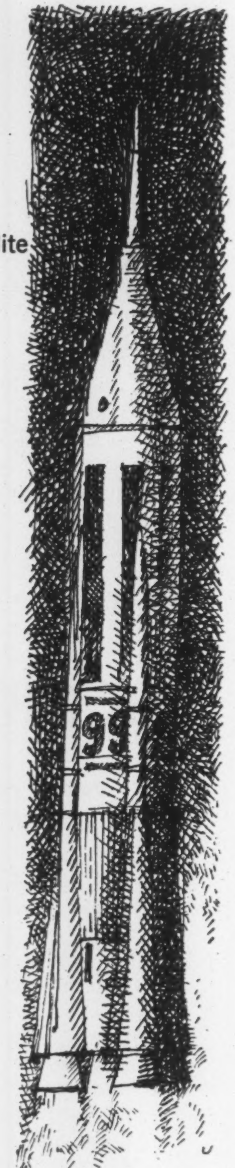
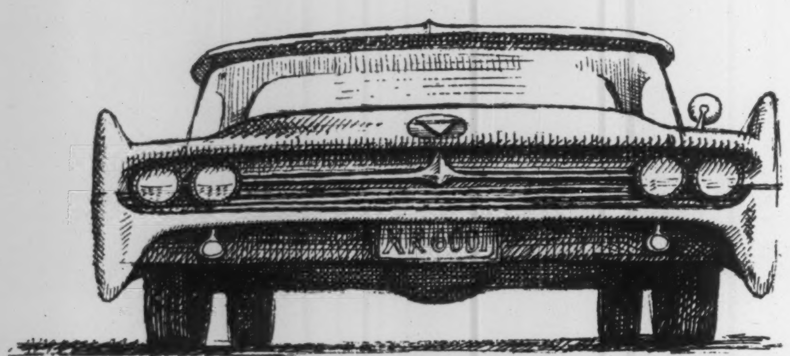


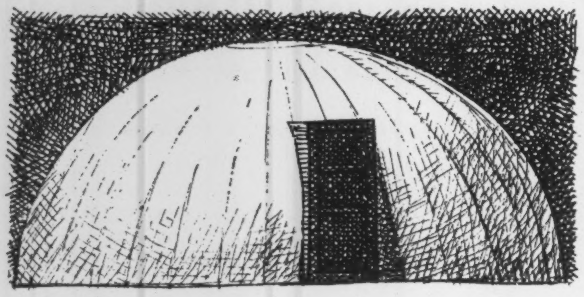
1 **CURON®** insulates huge vats

2 **OLIBOND®** helped orbit a satellite





3 **REEVECOTE®** helps pump the gas in millions of cars



4 **COVERLIGHT-V®** forms
an air house

Whatever you design
let REEVES' imagination help you make it better.

We're constantly developing new and improved materials for design applications. The latest development in a Reeves fiber, fabric or plastic may well be the answer to your problem in materials selection. Specify materials from Reeves... See how **Reeves makes good things better for you.**

1 multi-cellular plastic foam
2 self-bonding, non-conductive olefin fiber
3 diaphragms of Reevecote industrial coated fabric
4 vinyl-coated nylon fabric

REEVES

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DEEP WELLS OR SUMPS . . .

Rapidayton Pumps by Tait use top-quality tube by Wolverine

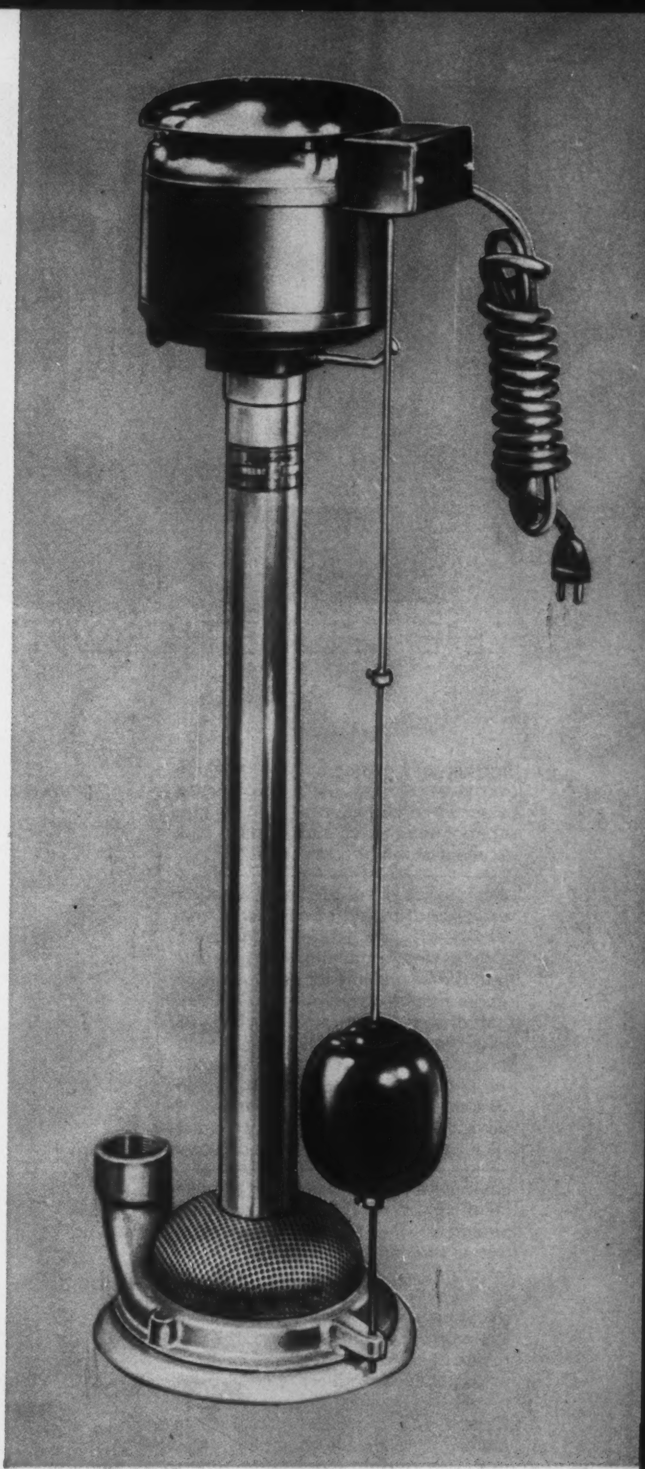
To a farmer pumping water from a 100-foot deep well, or to the owner of a flood-prone basement, such things as quality, stamina and dependability are highly desirable features in the pumps they use.

That's why Tait Manufacturing Company, Dayton, Ohio is so careful of the components it uses in its "Rapidayton" line of submersible and jet water systems and basement sump pumps. It's the reason, too, that Tait uses seamless brass and aluminum tubing manufactured by Wolverine Tube, Division of Calumet & Hecla, Inc.

For example, to resist corrosion, the critically important outer jackets of Rapidayton submersible pumps for both shallow and deep well use are formed from Wolverine soft annealed 2 and 1 low-leaded brass tube. Tait also uses thousands of feet of Wolverine half-hard 70-30 brass tube and 3003-H14 drawn aluminum tube for riser pipes on its Rapidayton Upright Cellar Drainers.

If your company uses seamless copper, copper alloy or aluminum tubing why not follow the lead of Tait and other American manufacturers—specify Wolverine.

Write, too, for a free copy of the Wolverine Tubemanship Book.



WOLVERINE TUBE
DIVISION OF
Calumet & Hecla, Inc.
DEPT. Q, 17258 SOUTHFIELD RD., ALLEN PARK, MICH.
TUBEMANSHIP in Copper—Copper Alloys—Aluminum—Special Metals

PLANTS IN DETROIT, MICHIGAN AND DECATUR, ALABAMA

SALES OFFICES IN PRINCIPAL CITIES

J-9948

For more information, circle No. 345

LUST

THE PLASTIC WITH THE RIGHT LEVEL OF

Starting just pennies above high impact styrene, new Lustran provides a balanced combination of light weight, superior toughness and rigidity, and excellent stability and colorability.

Check the range of the key properties, tensile and impact strengths, of typical Lustran formulations in the chart at right. One formulation will give you four times the impact resistance of rubber-modified styrene and ten times that of general purpose styrene. At zero degrees fahrenheit, a ⅛-inch thick 24-inch square sheet withstands the shock of a 6-pound ball dropped 48 inches. Lustran also gives excellent gloss, abrasion and chemical resistance, and comes in unlimited colors.

Lustran—a unique molecular arrangement of styrene, acrylonitrile and butadiene—has been successfully injection molded into parts weighing as much as 5 pounds and vacuum formed into deep-drawn parts weighing up to 11 pounds. If you are working on a design where the performance-cost balance is critical, write to us describing your requirements—or send for Lustran Progress Report and complete test data to Monsanto Chemical Company, Plastics Division, Department 834, Springfield 2, Massachusetts.

®LUSTRAN: T. M. Monsanto Chemical Company

Monsanto ®

MONSANTO designer in **PLASTICS**

RAN

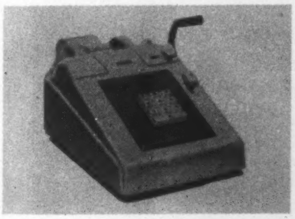
EFFECTIVE STRENGTH AT THE RIGHT COST

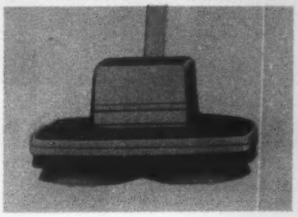
CHECK THE RANGE OF KEY PROPERTIES OF TYPICAL LUSTRAN FORMULATIONS:

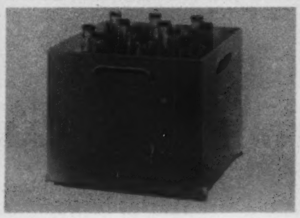
			MOLDING FORMULATIONS		EXTRUSION* FORMULATIONS		
PROPERTIES	TEST CONDITIONS	UNITS	210	710	261	761	ASTM
Tensile							
Stress at Yield	73° F.	psi	9,000	6,200	6,800	5,100	D638-58T
Stress at Failure	73° F.	psi	6,800	5,200	6,200	4,500	D638-58T
Elongation at Yield	73° F.	%	3.3	3.2	2.2	2.5	D638-58T
Elongation at Failure	73° F.	%	45**	70**	25	40	D638-58T
Modulus in Tension	73° F.	psi	420,000	300,000	380,000	290,000	D638-58T
Impact Strength							
Izod ½″ x ½″ Bar Mld. (.010″ Notch Radius)	73° F.	ft. lbs./in. of notch	1.1	4.3	0.9†	3.6	D256-56
	0° F.	ft. lbs./in. of notch	0.8	2.0	0.6†	1.5	D256-56
	−40° F.	ft. lbs./in. of notch	0.6	1.4	0.6†	1.1	D256-56
Izod ⅛″ x ½″ Bar Mld. (.010″ Notch Radius)	73° F.	ft. lbs./in. of notch	1.3–4.0	6.0–8.5			D256-56
	0° F.	ft. lbs./in. of notch	0.7–1.2	2.0–2.6			D256-56
	−40° F.	ft. lbs./in. of notch	0.6–0.8	1.1–1.8			D256-56

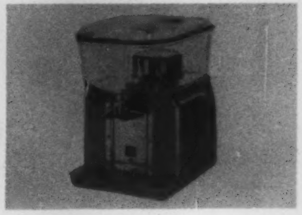
*Data on Extruded Sheet **Monsanto Test †½″ x 0.115″ Bar-Sheet

Lustran's combination of light weight, superior toughness and rigidity, excellent thermal stability, colorability, gloss, and abrasion and chemical resistance provides new opportunities for creative industrial design.









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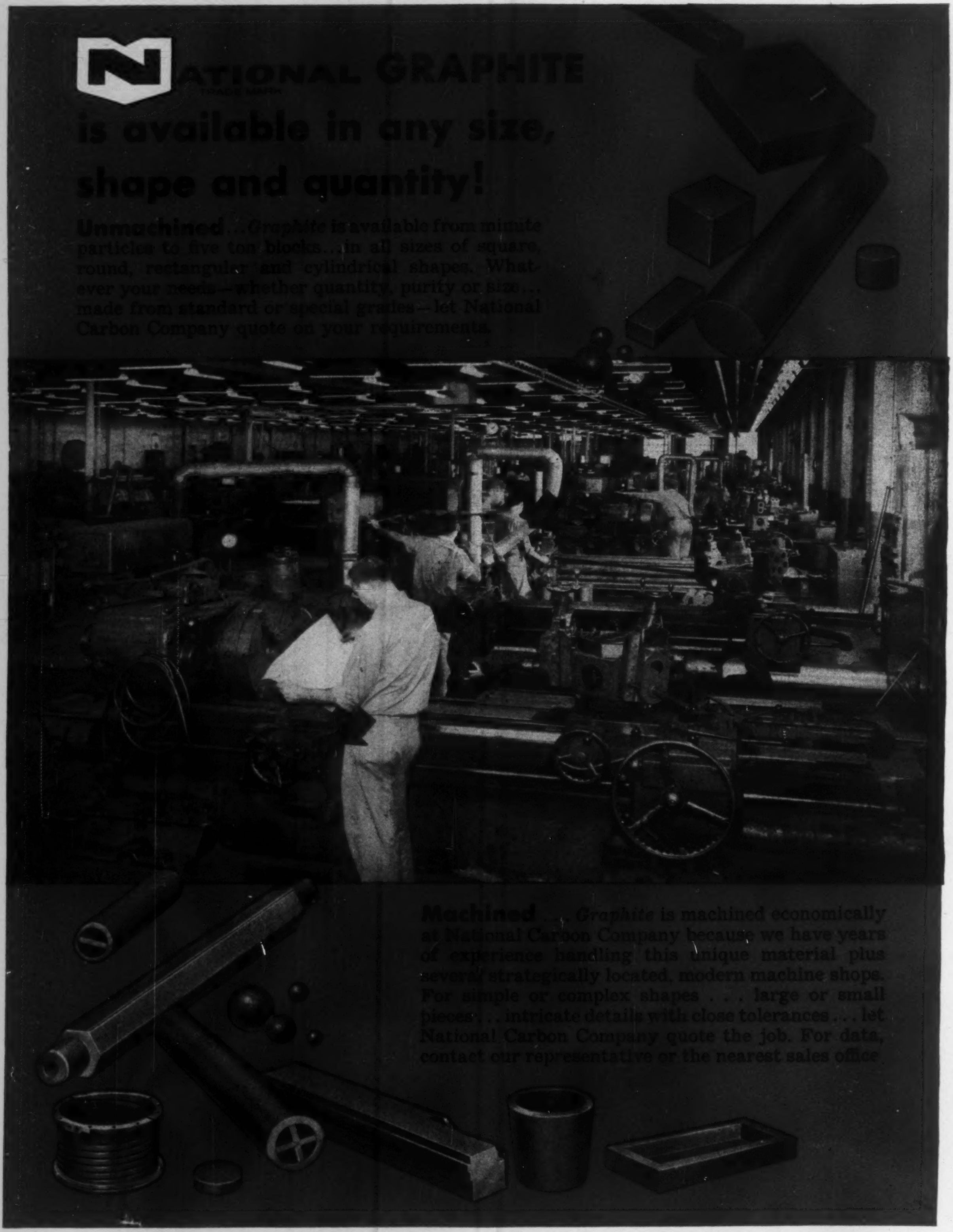

NATIONAL GRAPHITE

TRADE-MARK

is available in any size, shape and quantity!

Unmachined...*Graphite* is available from minute particles to five ton blocks...in all sizes of square, round, rectangular and cylindrical shapes. Whatever your needs—whether quantity, purity or size... made from standard or special grades—let National Carbon Company quote on your requirements.

Machined . . . *Graphite* is machined economically at National Carbon Company because we have years of experience handling this unique material plus several strategically located, modern machine shops. For simple or complex shapes . . . large or small pieces . . . intricate details with close tolerances . . . let National Carbon Company quote the job. For data, contact our representative or the nearest sales office.

"National" and "Union Carbide" are registered trade-marks for products of

NATIONAL CARBON COMPANY

Division of Union Carbide Corporation • 270 Park Avenue, New York 17, New York

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UNION CARBIDE

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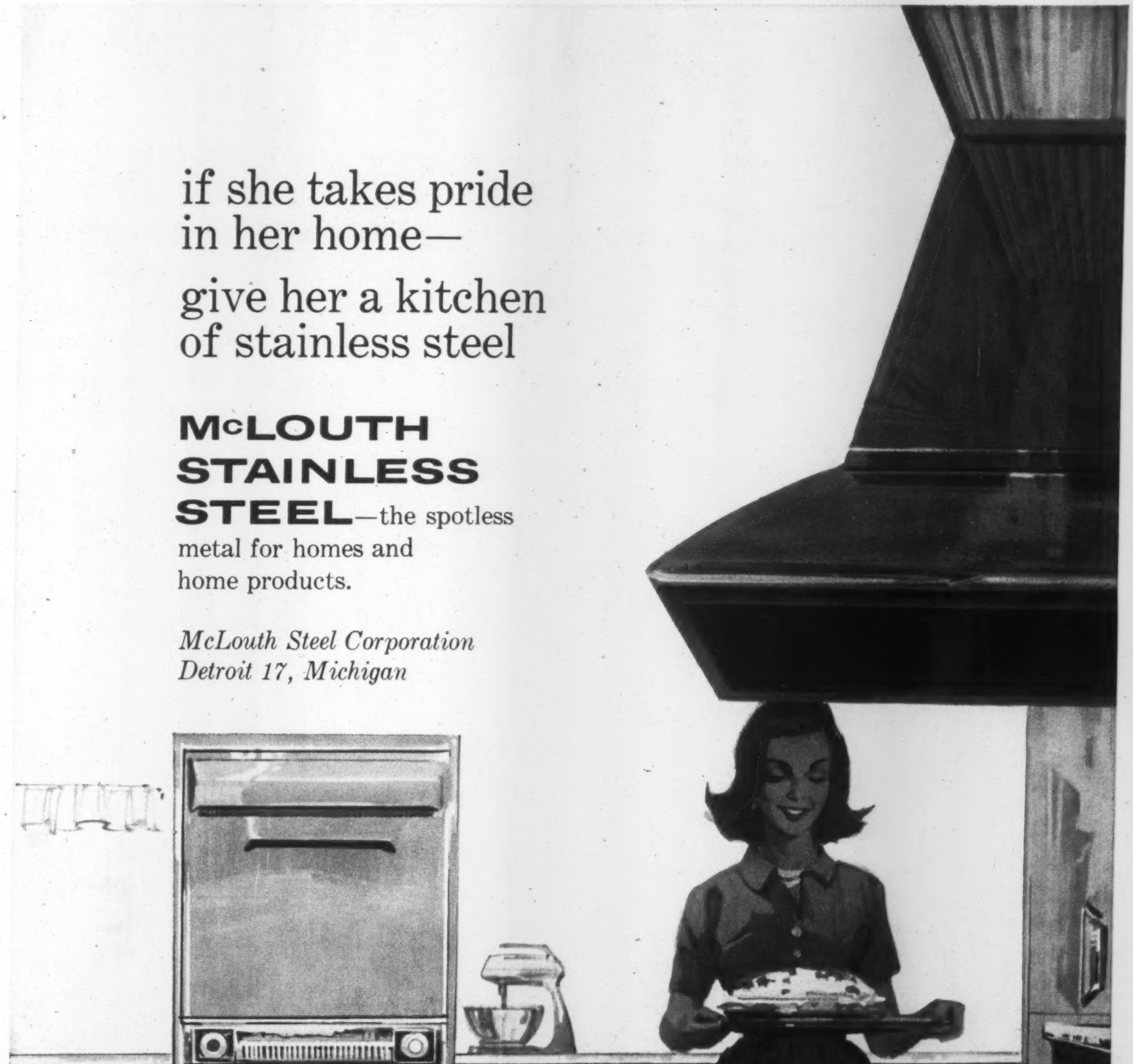


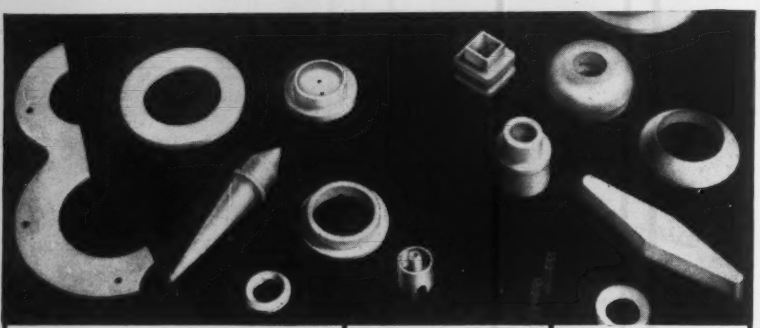
if she takes pride
in her home—

give her a kitchen
of stainless steel

**McLOUTH
STAINLESS
STEEL**—the spotless
metal for homes and
home products.

*McLouth Steel Corporation
Detroit 17, Michigan*

PLASTICS
in Design Engineering



PROPERTY	TEFLON (TFE)	TEFLON (FEP)
Specific Gravity	2.1-2.2	2.1-2.2
Tensile Strength, 73°F	2500-3000 psi$^{(a)}$	2700-3100 psi
Elongation, 73°F	100-200%	250-330%
Compressive Stress at 1% Offset	1000 psi	700 psi
Impact Strength, Izod Notched, 77°F	3.0 ft. lb./in. of notch	Does not break
Heat Distortion Temp., 66 p.s.i.	270°F	162°F
Coefficient of Linear Thermal Expansion (Approximate Values per °F)	5.5 x 10^{-5} in./in./°F	5.23 x 10^{-5} in./in./°F
Dielectric Strength, Short Time, 1/16″	400-500 v/mil$^{(b)}$	400-500 v/mil$^{(b)}$
Surface Arc-Resistance	700 seconds$^{(c)}$	165 seconds$^{(d)}$
Volume Resistivity	$>10^{15}$ ohm-cm.	2 x 10^{15} ohm-cm.
Dielectric Constant (60 Cycles)	2.0	2.2
Service Temperature Range (Max.)	+500°F	+400°F
Service Temperature Range (Min.)	−395°F	−395°F
Water Absorption	0.0%	0.0%
Flammability	Nonflammable	Nonflammable

(a) Tensile strength in oriented film may be as high as 15,000 psi.

(b) Value is 1000-2000 v/mil in thicknesses of 5 to 12 mils.

(c) Does not track.

(d) Samples melted in arc after 15 seconds, but did not carbon track.

This table compares the properties of Teflon* TFE and FEP. The newer FEP can be injection molded. In designing, consult your Garlock plastics specialist for best application results.

In designing intricate parts, consider the benefits of Teflon as a material.

Teflon offers a unique combination of properties unmatched by other plastics. It possesses the lowest coefficient of friction, the best non-stick characteristics, the most complete chemical resistance and the widest useable temperature range available in any plastic. Teflon eliminates lubrication, corrosion, contamination, seizing; it reduces friction, wear, space required, weight. Teflon can be used in a thousand different ways—for packings, gaskets and seals . . . for connectors, insulators, and test points . . . for valves, bearings, couplings, and insulation.

In producing intricate Teflon parts, consider the benefits of Garlock as a supplier. From virgin powder to finished piece, Garlock closely controls each step in the process to assure that the final part performs to your expectations. Complete facilities are at your disposal for molding, extruding, and machining of Teflon. If your application calls for special properties, Garlock will compound Teflon with selected fillers to greatly extend its service range. If you need unusually large configurations, Garlock will fusion-weld Teflon . . . the weld will have the same thermal, chemical and electrical properties as the Teflon itself.

Parts made from Nylon, Delrin*, C.T.F.E., Lexan† are also available from Garlock. Let your local Garlock representative quote on your design, or ask his assistance on any design problems concerning materials and applications. Call him at the nearest of the 26 Garlock sales offices throughout the U.S. and Canada. Or, write for Catalog AD-177. Garlock Inc., Palmyra, N.Y.

GARLOCK

Canadian Div.: Garlock of Canada Ltd.

Plastics Div.: United States Gasket Company

Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Products.

*DuPont Trademark
†General Electric Trademark

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Bethlehem makes just about every kind of

STEEL WIRE

Some are general-purpose grades; others are made for specific applications. If you want information on steel wire, just mail us the coupon below.

1. alloy
2. armor
3. ball
4. bed spring
5. bethanized
6. bicycle spoke
7. border
8. bright basic
9. brush handle
10. cable lashing
11. chain link fence
12. clean bright
13. clothes pin
14. coat hanger
15. cold-heading
16. core (ACSR)
17. extra smooth clean bright
18. fence
19. foundry core
20. galvanized
21. hog ring
22. hose
23. link
24. mechanical spring
25. pail bail
26. rivet
27. rope
28. "scrapless nut"
29. screw
30. screwdriver
31. shaped
32. spoke
33. staple
34. strap
35. strand
36. telephone
37. tire chain
38. upholstery spring
39. welding
40. wool

TABLE OF EQUIVALENTS

STEEL WIRE SIZES AND WEIGHTS

BETHLEHEM STEEL

BETHLEHEM, PA.

SALES OFFICES IN PRINCIPAL CITIES

Steel

for Strength

... Economy

... Versatility

Free Wall Chart

This 18 x 36-in. sheet steel wall chart gives decimal equivalents, wire sizes, and gages from 7/0 to 24¾, with corresponding decimal sizes, lb per ft, and ft per lb. For your free chart, just fill out and mail us the coupon.

BETHLEHEM STEEL

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Sales: Bethlehem Steel Export Corporation

For more information, circle No. 408

PUBLICATIONS DEPARTMENT
BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Dear Sirs:

Please send me information on type of wire circled.

1 6 11 16 21 26 31 36
2 7 12 17 22 27 32 37
3 8 13 18 23 28 33 38
4 9 14 19 24 29 34 39
5 10 15 20 25 30 35 40

and ______________________________.

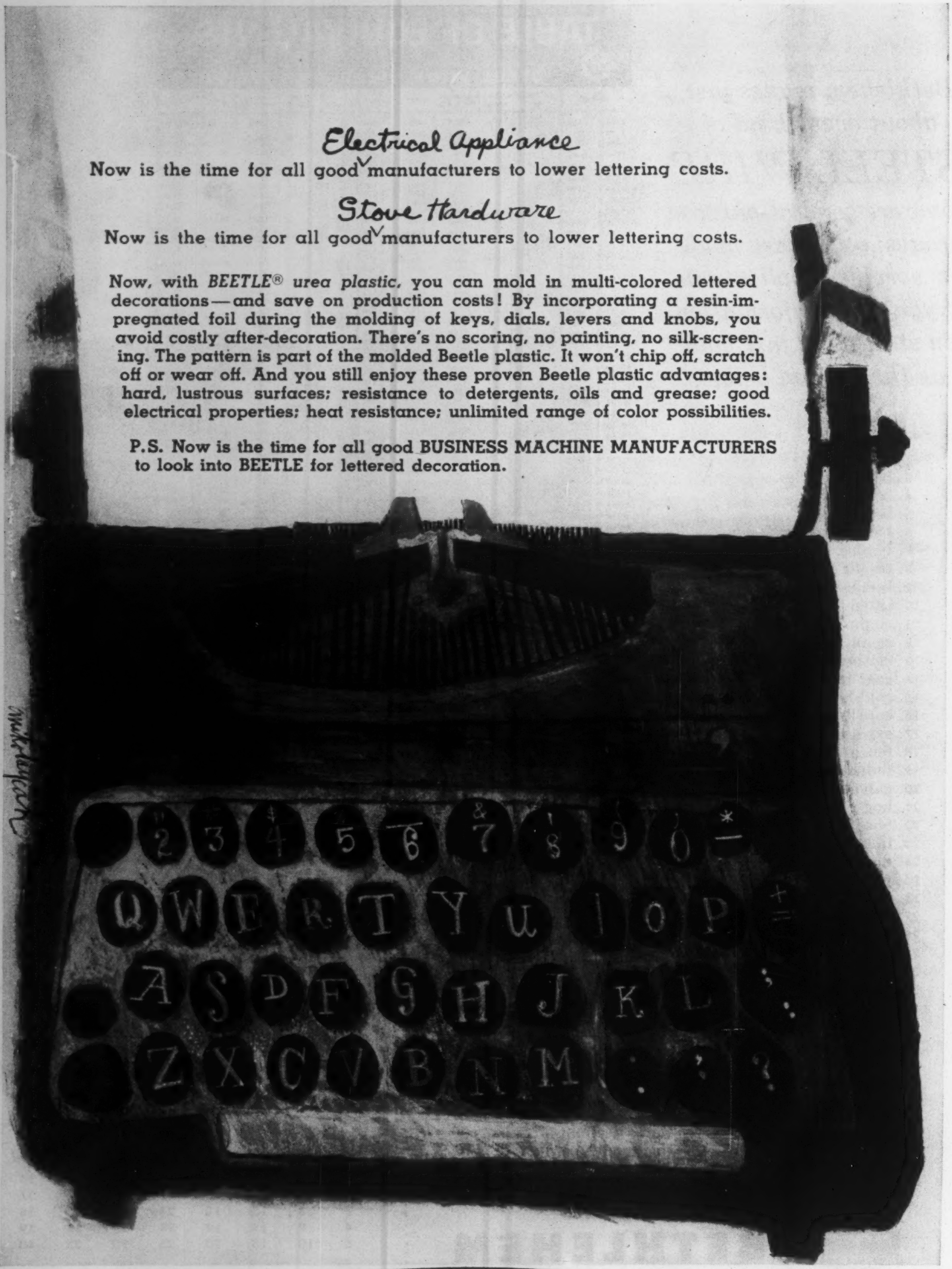
☐ *Please send "Table of Equivalents" wall chart.*

Name ______________________________

Firm ______________________________

Street ______________________________

City ____________________ Zone ________ State ________



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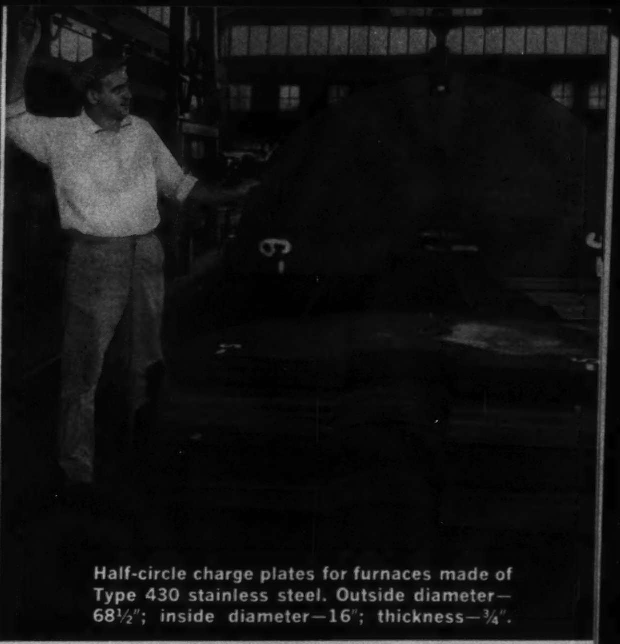
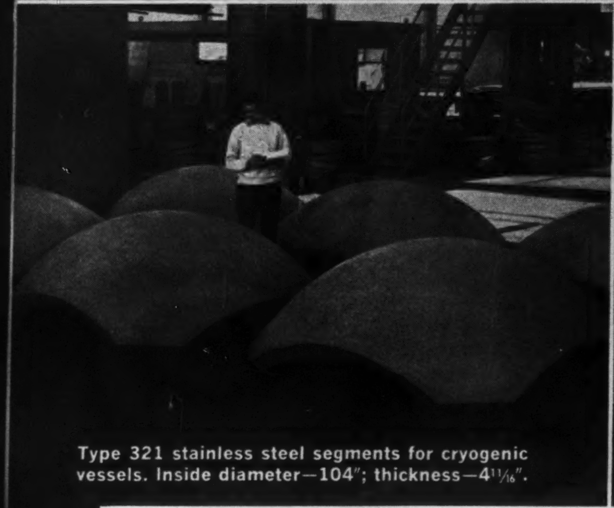
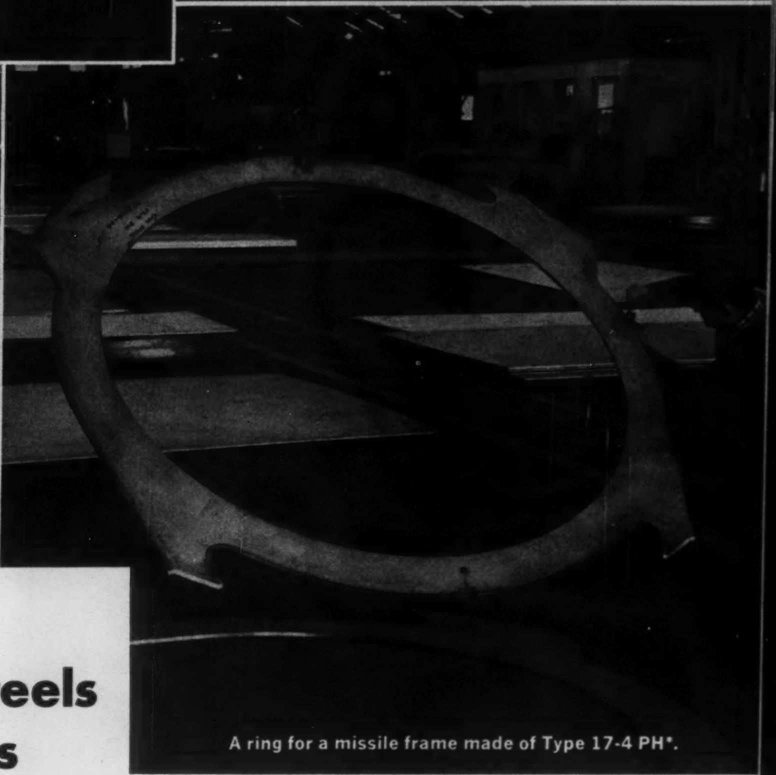
Indexing plate for nuclear storage cask. Type 304. Outside diameter—44⅜"; thickness—2¾".



Half-circle charge plates for furnaces made of Type 430 stainless steel. Outside diameter—68½"; inside diameter—16"; thickness—¾".



Type 321 stainless steel segments for cryogenic vessels. Inside diameter—104"; thickness—4 11/16".



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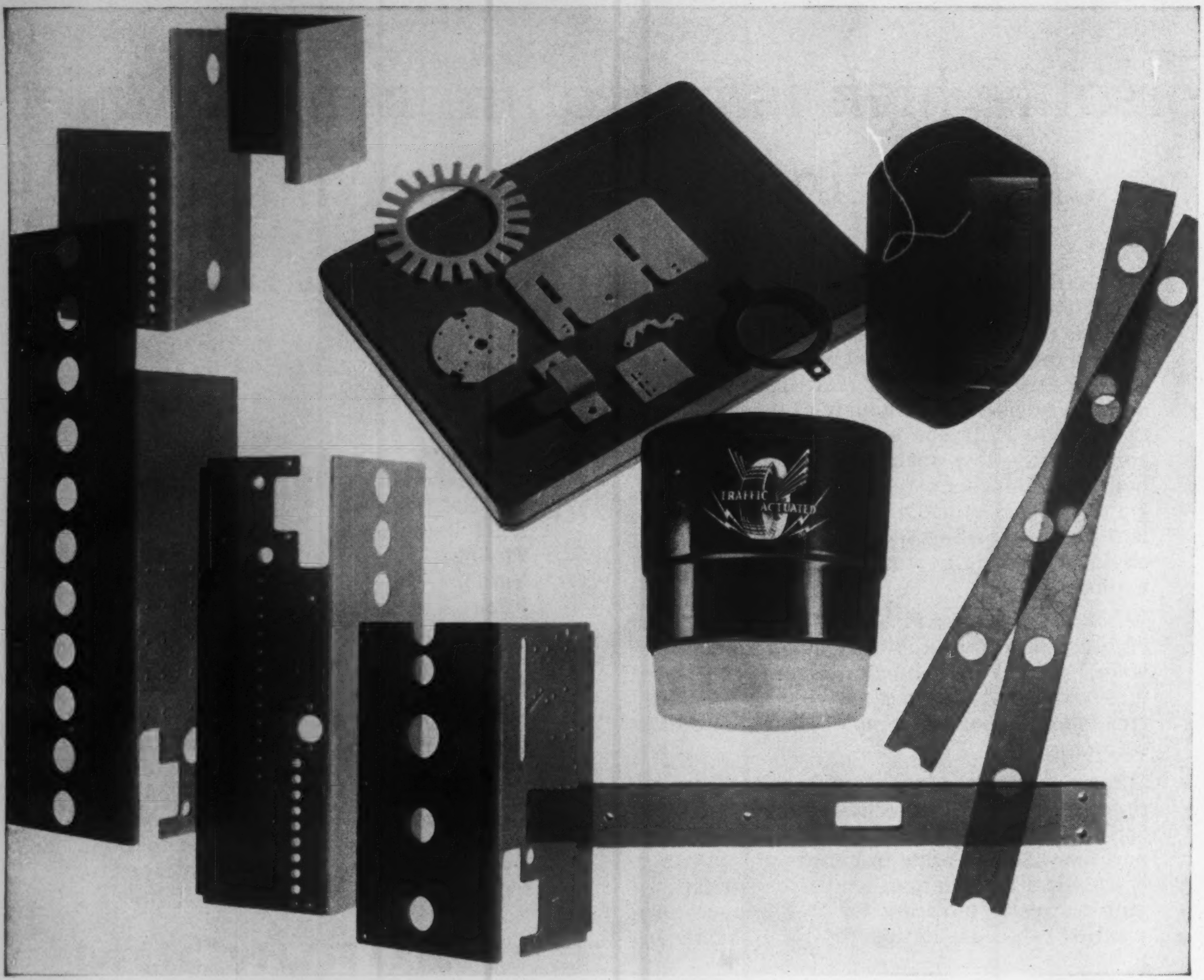

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SILICOLOGY *Studies in Silicones*

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Need a big-muscled spring to fit a pint-size space? You can now get a fluid spring 1/40 the size of an equivalent coil spring. Need a hydraulic shock absorber with a "flat-topped" energy absorption curve between minus 60 and plus 500 deg. F.? You can now get it. Want the two in one unit? You can get that, too.

The common denominator of such high-performance devices is a series of UNION CARBIDE Silicone Fluids. They range in viscosity from 10 centistokes to 100,000, with pour points as low as minus 85 and flash points above 600 deg. F.

MILLION POUND CAPACITY. This revolutionary, patented 1,000,000-pound Taylor liquid spring utilizing the precisely known compressibility of UNION CARBIDE Silicone Oil, is said to be the highest force spring ever produced in a single unit. Only a foot in diameter, it could support three of the largest locomotives. On top of it sits Taylor's smallest liquid spring. Beside it is a locomotive coil spring of almost the big spring's size, but providing only 10 tons of force.

COMPRESSIBILITY PLUS STABILITY

Two of silicone fluids' outstanding properties contribute greatly to their growing usefulness in a variety of hydraulic devices including springs, shock absorbers, torque convertors, dash pots, valve lifters, many more. These are compressibility—the highest known for polymeric fluids—combined with stability at temperature extremes.

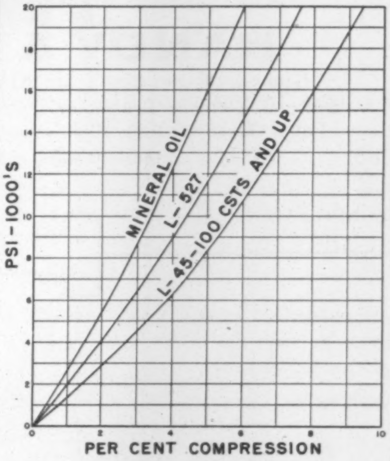
The per cent compressibility of UNION CARBIDE L-45 and L-527 Silicone Fluids, compared to conventional mineral oil, is shown in the accompanying chart. The viscosity temperature coefficient $\left(1-\frac{V210°F.}{V100°F.}\right)$ for L-45 with nominal viscosity of 100 ctsk. is 0.63.

NAME YOUR OWN SPRING RATE

Taylor Devices, Inc., of North Tonawanda, N. Y., is one of the companies adapting these highly useful qualities to hydraulic equipment. In tension and compression devices, for example, using a stepped tubular piston design and L-45 fluid, they achieve virtually any desired spring rate and force, within a compact, structurally stable mechanism.

Again, in spring-shock absorbers where high mechanical energy is converted to heat energy, Taylor Devices find UNION CARBIDE Silicone Fluids greatly extend the useful work range of the units.

Among the jobs such devices are performing are: Scram-rod cushions in nuclear reactors, taking impact loads on aircraft arresting hooks, cushioning aircraft radar antennas. In addition, they arrest circuit breaker mechanisms at interruption, stop rolls of paper on paper machines, and control feed rate of electrodes on electric furnaces.



Compressibility of UNION CARBIDE Silicone Fluids vs. Mineral Oil

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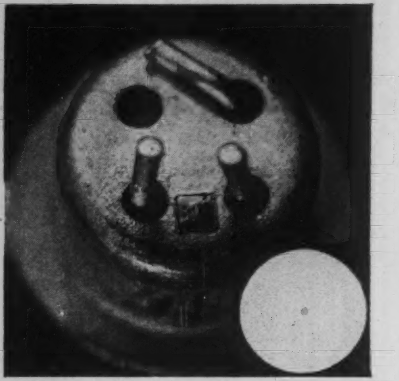
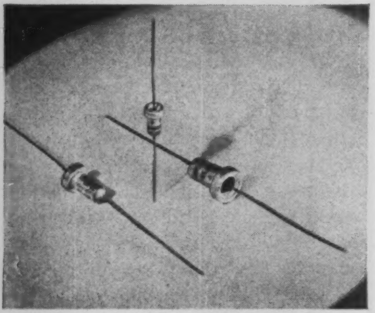
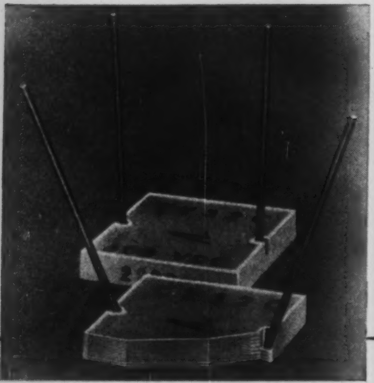


TRANSISTORS—Shown here in magnification is a Mesa transistor with fine gold wire. Handy & Harman manufactures this whisker wire to exact tolerances and highest purity standards. The cap is gold plated from Handy & Harman fine gold anodes. Photo courtesy of Western Electric.



CAPACITOR CANS—These tantalum electrolytic capacitors are completely leaktight and highly resistant to corrosion. The containers that are also used to seal the liquid and internals are drawn from Handy & Harman fine silver sheet. Photo courtesy of Fansteel Metallurgical Corporation, North Chicago, Ill.



CAPACITORS—Electrodes in these solid-state porcelain capacitors are formed from silver paste derived from Handy & Harman silver flake. Other types of capacitors for high-temperature applications have lead wires of Handy & Harman Consil 998, a nickel-bearing alloy. Photo courtesy of Vitramon, Incorporated, Bridgeport, Conn.

TRANSISTORS, CAPACITORS AND COME WHAT MAY

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MATERIALS ENGINEERING & DESIGN

...AT A GLANCE

Three refractories withstood a Mach 2 jet for 2 min in a recent test with a stagnation temperature of 380° F. They are silicon carbide–silicon, chromium–28% alumina cermet, and titanium boride–5% boron carbide, three of 22 refractory materials investigated for missile and reentry vehicle requirements. The test consisted of four 30-sec exposures; specimens were evaluated for deterioration caused mainly by oxidation.

Source: Technical Note D-906, National Aeronautic and Space Administration, Washington, D. C.

Two nontoxic rust preventives are as effective as red lead and other common inhibitors, a recent study shows. The chemicals, calcium and zinc molybdates, are white in color and should be useful in piping and containers for food and drinking water.

Source: Battelle Memorial Institute, 505 Kings Ave., Columbus 1, Ohio

Lightweight, rigid insulating linings for use to 2300 F—or higher for a limited time—have been developed for ducts, pressure vessels, molten metal systems and induction furnaces. They are tubes made of laminated ceramic fiber papers, called Fiberfrax, and are variously processed for mechanical or thermal shock or surface compressibility.

Source: The Carborundum Co., Refractories Div., Perth Amboy, N. J.

Pearlitic malleable iron has been accepted for 81-mm shell bodies, replacing steel forgings. Acceptance of the castings has resulted from improvements in quality control: more uniformity between melts, closer dimensional control, and ultrasonic inspection for soundness. Malleable iron can be machined more easily and has a better shrapnel effect.

Source: Malleable Founders Soc., 781 Union Commerce Bldg., Cleveland 14, Ohio.

A one-piece gas turbine diaphragm has been investment cast. Compared to the current practice of fabricating diaphragms from individual rings and vanes, this unique construction is reported to allow cost reduction, greater design flexibility and a broader selection of alloys.

Source: Austenal Co., 230 Park Ave., New York, N. Y.

A technique for high-strength bonding of metal to glass has come out of recent development efforts on aircraft windshields. Loads up to 3300 lb per linear inch of bond line at room temperature (and 500 lb at 500 F) have been held by Metlbond 302 adhesive joining Corning Code 1723 glass to Kovar side members. Transmitting tensile loads to glazing through this type of configuration is a controversial design concept.

Source: Corning Glass Works, Corning, N. Y.

An air melted cobalt alloy may beat vacuum melted nickel alloys for some high temperature applications, recent stress rupture data indicate. In the range of 1800 to 2000 F, air melted WI-52 is claimed to come close enough in strength to vacuum melted nickel alloys that it deserves serious attention because of its lower cost and excellent casting characteristics.

Source: Waimet Alloys Co., 5320 Oakman Blvd., Dearborn 2, Mich.

m-m-m-m-m--

Equipment parts are better and materials engineering improved by the powder metallurgy process

Another example of product improvement. This barbecue part was fabricated by Metal Ceramics Company, Melrose Park, Illinois.

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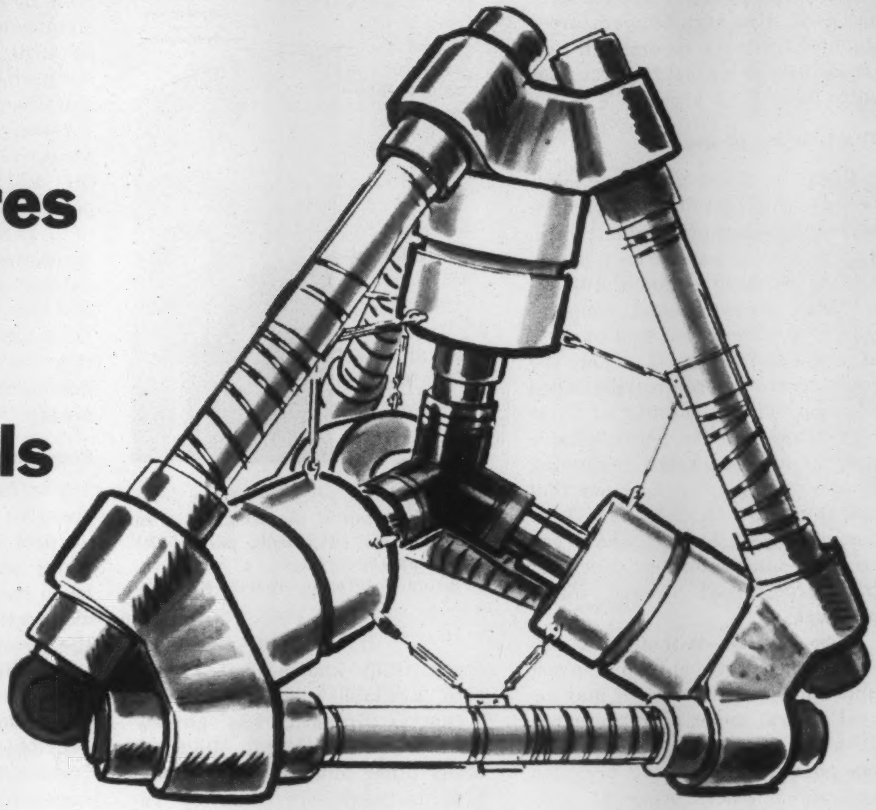
Ultra High Pressures Create New Materials



by Donald Peckner,
Associate Editor,
Materials in
Design Engineering

The Tetrahedral anvil; see p 116

The advent of the synthetic diamond signalled the emergence of a new and exciting tool—ultra high pressures ranging as high as 3,000,000 psi. Practical applications are few at present, but in the future you can look for new materials... improved properties... perhaps even a whole new periodic table.

■ Is it possible for man to squeeze an atom so hard that its outermost electrons are forced into vacant inner shells?

There is plenty of evidence to suggest that it is not only possible but is actually being done in a number of laboratories today. So far no one has succeeded in making such changes irreversible and thus of practical use, but the possibilities are a heady draught.

For all practical purposes, a new periodic table would be created. The ordinary chemical and physical properties of the elements would be so changed as to be unrecognizable, according to Dr. H. T. Hall, a leading investigator of high pressure phenomena.

How much pressure?

This is only one possible result of widespread work now being done on the effects of ultra high pressures on materials. There are many others of interest to engineers.

But first, what kind of pressures are we talking about?

Some researchers have reported pressures up to 400,000 atm, i.e., almost 6,000,000 psi. This is equivalent to the pressure that would be exerted by a granite column 800 miles high—more than 7500 times the height of the Washington Monument.

Such pressure is far beyond any that man has ever achieved before. But it is still a gentle squeeze next to the 3,000,000 atm of pressure at the center of the earth (see Fig 1), and hardly worth noticing next to the 100,000,000,000 atm at the center of the sun.

Further work may narrow the gap between man-made and natural forces to some small extent. But at the moment the most promising applications for ultra high pressures seem to lie well within the range of pressures presently obtainable. Most of the men interviewed for this article felt that the bulk of industrial applications would fall in the 25,000 to 50,000 atm range, i.e., about 370,000 to 730,000 psi.

(continued on next page)

◄ For more information, circle No 404

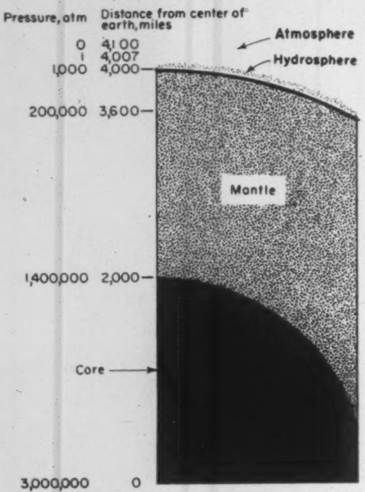
Most high pressure applications also need ultra high temperatures. Much of the work reported in this article uses temperatures ranging up to 3500 F or higher.

The four major uses

From a materials standpoint, the potential benefits of ultra high pressure technology seem to fall into four main categories:

New materials—Combining ultra high pressures and temperatures has already led to a number of new materials, most notably the cubic form of boron nitride called Borazon. The possibility of drastic additions to the periodic table was mentioned at the beginning of this article. Fig 2 shows that two-thirds of the elements have "empty" inner orbits which can accommodate outermost electrons that are forced inward under pressure.

New phases—Although a material may have only one phase under normal pressure, it may reveal several under high pressures. Bismuth, for example, has only one phase at atmospheric pressure, but seven others occur at pressures up to 90,000 atm. So it is possible that ultra high pressures, with or without heat treatment, may develop new phases of elements and compounds having hitherto unobtainable properties.

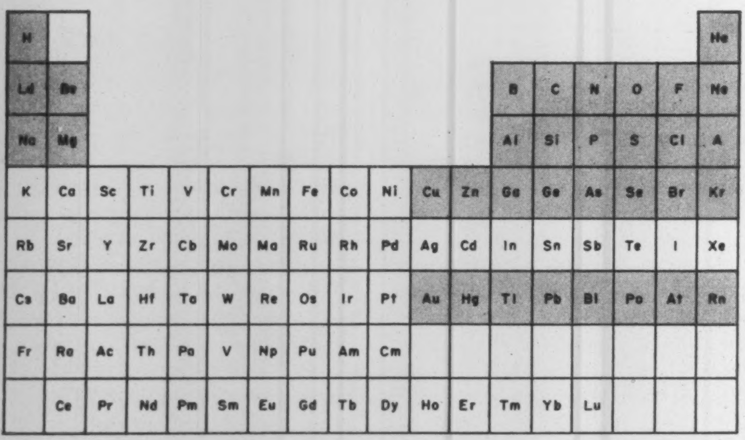


1—*Terrestrial pressures range from zero at the top of the atmosphere to 3,000,000 atm (44,000,000 psi) at the center of the earth.*

(H. T. Hall, "Ultra High Pressures.")

A related effort: to produce synthetically known phases hitherto available only in natural products. Graphite has already been transformed into diamond. Many other minerals, less important to engineers than to researchers, have also been synthesized.

Better properties—High pressures inhibit grain growth and promote uniform heat treatment in metals. Subjecting materials to ultra high pressures at either room or elevated temperature may significantly increase such mechanical properties as fatigue strength, yield strength, ductility and creep resistance.



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	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu			

2—*Periodic table shows elements that potentially can have outer electrons forced into "empty" inner orbits. Entirely new physical and chemical properties would be developed. Unaffected elements are shaded.* (U.S. Air Force)

Denser materials—Using high pressures in combined hot pressing and sintering may produce powder compacts only a few tenths of a percent less dense than the theoretical maximum. This is a natural area for the metallurgist and the ceramist to investigate.

In the next section of this article we will look briefly at what has been accomplished in these areas.

Economics and the future

The future importance of high pressure technology in the materials field is hard to estimate. It depends not only on the results of basic research now under way but also on the ingenuity of those who are developing equipment to generate ultra high pressures.

So far, much of the work has been done on very small specimens —cylinders about ½ in. high. New presses in the offing promise to increase specimen length to as much as 20 in. But there is no solution yet to the problem of applying such pressures on a continuous rather than batch basis.

More fundamental is the problem of reversibility. Much depends on whether important changes that occur under pressure can be made irreversible.

Still other problems are of a more technical nature. In particular, more accurate measurement of pressure and temperature will be needed if the data obtained in one investigation are to have any meaning in the next.

At present, it is safe to say that the cost of generating ultra high pressures is sufficiently high, and facilities sufficiently scarce, that the process is suitable only for low volume applications where the results achieved are almost "priceless." So far, synthetic diamond is still the only important commercial application. But chances are this hard stone is only the first tiny step for a truly new engineering tool.

Here is what has been done

To catalog here the full range of high pressure experiments would be impossible. But following are the highlights of what has been done in the way of creating new materials and phases, as well as changing the properties of materials.

Although most of the discussion is concerned with metals, inorganic materials are being intensively investigated by geophysicists who are interested in finding out how various minerals were formed. And organic chemists are just beginning to work on the effect of ultra high pressures on both the synthesis of new materials and the reaction rates of chemical processes.

Five new materials

Two new materials, synthetic diamond and Borazon, have already been mentioned. Here are a few details on these and three others:

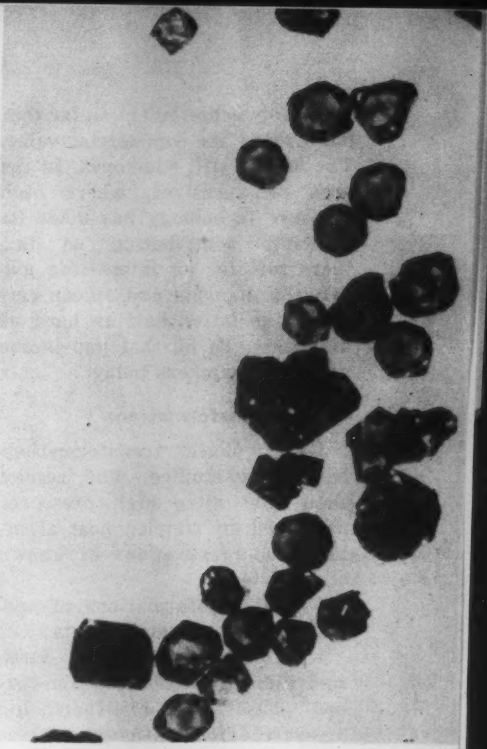
1. *Diamond* — General Electric Co. announced the synthesis of diamond in 1955. Since then many other investigators have duplicated this achievement.

In addition to high pressure and temperature, a metal catalyst such as nickel is required. With laboratory-scale equipment, only 1 min at the proper combination of pressure and tempreature is needed to form diamonds such as those shown in Fig 3.

Although man-made diamonds are as expensive as natural ones, they can be made more angular, and therefore more efficient as abrasives. Current work is in three directions: lowering cost, increasing size, and creating extremely pure diamonds for use as semiconductors.

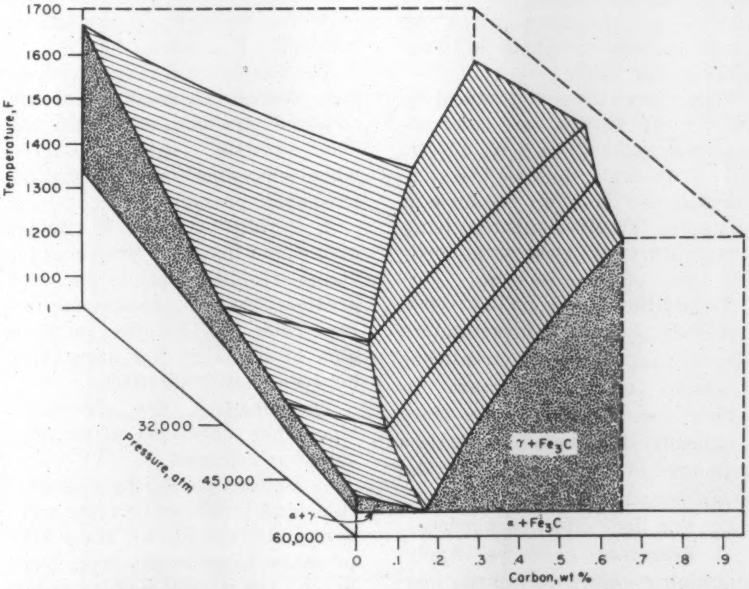
2. *Borazon*—Also developed by GE investigators, this material is a cubic form of boron nitride. It scratches diamond, retains its hardness at temperatures higher than those at which diamond is stable, and does not burn in oxygen. Borazon was first announced in 1957.

3. *Coesite*—A dense form of silica that had not been previously observed in nature, coesite was synthesized in 1953 by Lauren Coes, of The Norton Co. The new mineral has a specific gravity of 2.90, compared to 2.65 for quartz. Although it has no commercial application at present, it holds some promise because it is less reactive than normal quartz and is not attacked even after long heating in hydrofluoric acid.



(Courtesy Dr. W. G. Field)

3—*Single crystals of diamond.*



4—*Three-dimensional iron-carbon diagram shows how pressure lowers the eutectic temperature and shifts the eutectic point to lower carbon content.*

(Adapted from Hilliard and Tully)

Since Coes' work, coesite has been found in locales that had at one time or another been subjected simultaneously to high pressures and temperatures, notably meteor impact sites and nuclear test sites. A good example is Meteor Crater, south of Rimmy Jims, Ariz.

4. *Molybdenum carbide* — This material (MoC) has been synthesized by Manufacturing Laboratories, Inc. It has potentially interesting properties but data are not yet available.

5. *Tantalum nitride*—A new cubic form of tantalum nitride (TaN) has been created at the Army Signal Corps' Research and Development Laboratory. The material has superior chemical and thermal properties compared to the normal hexagonal structured tantalum nitride.

Although synthesis of new materials is an important aim of high pressure technology, diamond is the only achievement so far that has proved its commercial value. The field is still wide open. In the area of abrasives, where high pressure technology has made its principal contribution so far, there remains an interesting gap between diamond and silicon carbide (the latter half as hard as diamond). To fill that gap is one aim of researchers today.

Phase transformations

Many phase transformations have been studied. The results show that ultra high pressures may lead to simpler heat treatments and extensions of known alloy systems.

Three transformations of special interest to metallurgists:

1. *Iron-carbon diagram*—Pressure radically affects the iron-carbon phase diagram. Increasing pressure from atmospheric to about 60,000 atm (870,000 psi) lowers the eutectic temperature from 1335 F to 1076 F and shifts the eutectic point from 0.83% carbon to approximately 0.18% (see Fig 4). These changes are reversible, but someday they could mean simpler, lower temperature heat treatment of steel.

2. *Martensite-austenite*—Pressure lowers the temperature at which martensite begins to form on quenching (M_s) and the temperature at which austenite begins to form on heating (A_s).

3. *Gamma loop*—Pressure extends the gamma loop in the phase diagrams of iron-chromium, iron-aluminum and iron-silicon alloys. With iron chromium, for example, the loop shifts from 12% chromium to 20% at about 100,000 atm pressure. Thus the range of heat treatable alloys in existing alloy systems can be extended.

TABLE 1—ROCKWELL C HARDNESS AND GRAIN SIZE: 1 ATM VS 100,000 ATM HEAT TREATMENT

Austenitizing Temp, F	1 atm			100,000 atm		
	Q	T	G	Q	T	G
2000.....	61.5	63	NV[b]	61.5	63	NV[b]
2300.....	65.5	66	11	64	66	11
2400.....	62	64	3	66	63.5	11
2500.....	—	—	—	60	—	5
2600.....	—	—	—	60	—	3

[a] T5 high speed steel. Key: Q—quenched hardness; T—hardness after tempering at 900 F; G—grain size.
[b] Not visible.
Source: E. W. Goliber, et al., WADC Rpt. 59-74-7.

TABLE 2—EFFECT OF 10,000 ATM PRESSURE ON SIX METALS[a]

Metal ⬇	Rigidity Change, %	Compressibility Change, %
Steel.........	+2.2	+ 7.2
Tungsten......	−0.3	+ 8.8
Tantalum......	+0.3 to +1.5	+ 1.1
Molybdenum...	+0.15	+ 6.9
Platinum......	+2.4	+10.0
Nickel........	+1.8	+ 7.9

[a] Actually 10 kilobars pressure.
Source: P. W. Bridgman, *The Physics of High Pressure*, Bell and Sons, '52, p 385.

Increasing cohesion

In general, the broad effects of pressure and temperature are diametric opposites. Temperature increases the distance between atoms; pressure decreases it. Thus, to obtain many reactions it is necessary to use ultra high temperatures to compensate for the slowdown in reaction rates resulting from the ultra high pressure.

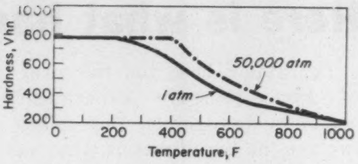
Here are the results of four experiments, the majority of which illustrate how reactions can be retarded by ultra high pressure:

1. *Grain growth* — Austenitizing a high speed tool steel under 100,000 atm pressure raised the grain growth threshold at least 100 °F (see Table 1).

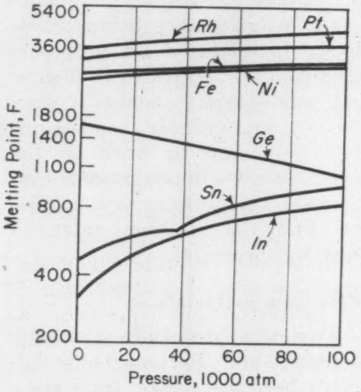
Grain growth is a problem in such steels. In this case composition was: 0.77 C, 18.5 W, 4.5 Cr, 2 V, 1 Mo, 9 Co. Because the alloy carbides are relatively insoluble in austenite, specified austenitizing temperatures are close to the melting point of some phases.

In addition to less grain growth, General Electric investigators found that pressure treatment produced a microstructure in which the carbides were more uniformly distributed, with less evidence of coalescence at the grain boundaries. Pressure treatment had little effect on hardness.

2. *Tempered hardness*—Applying high pressure during the tempering of quenched iron-carbon alloys strongly retarded the expected fall in hardness for tempering temperatures above 212 F, according to investigators at Manufacturing Laboratories, Inc. The maximum pressure effect occurred in the 390 to 570 F range (see Fig. 5). Pressure had little effect for tempering temperatures below 212 F or above 930 F.



5—*Difference between hardness at 50,000 atm and 1 atm for an iron—0.41% carbon alloy. All specimens tempered for 30 min.*
(Manufacturing Laboratories, Inc.)



6—*Melting curves of various materials.* (W. G. Field)

The temperature range in which the greatest hardness difference occurred is identical with the "blue brittle" range observed when tempering under normal atmospheric pressure.

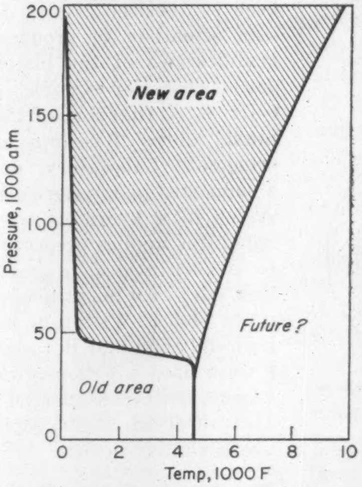
3. *Rigidity*—Dr. P. W. Bridgman found that high pressures increase rigidity and, to an even greater extent, compressibility (see Table 2). The effect on modulus of elasticity lies somewhere between these two effects.

The changes are significant since they developed after pressure was released.

4. *Melting point*—As a general rule, high pressures increase melting points (see Fig 6). Many high pressure experiments have gone beyond the normal melting points of the chamber and thermocouple materials.

Presses, pressures and problems

As indicated earlier, the future of high pressure technology hinges to a considerable extent on advances in the design of machines. Already a vast new area of pressure and temperature has been opened up, as Fig 7 indicates. But, although the pressures presently obtainable appear to be high enough for most practical applications, the forms and sizes of materials that can be processed are severely limited (see Fig 8).



7—*Belt apparatus has extended the pressure and temperature range.*
(H. T. Hall, "Chemistry at High Temperature and High Pressure.")

Let's take a closer look at what can be done today and in the immediate future.

Research vs industrial

First, it will be helpful to distinguish between research efforts and that work which is directed toward commercial application. Much research is being done at pressures of 100,000 atm and above. Cutting pressure back to about 50,000 atm offers a number of advantages:

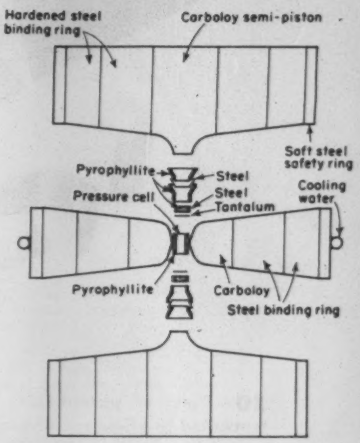
1. It increases by four or five times the volume of material that can be treated.
2. It makes feasible a simple piston-cylinder arrangement which lowers production expenses.
3. It drastically reduces calibration problems.

Nonetheless, the size of specimen or part that can be produced by a piston-cylinder device appears to be limited; scaling up presses and dies to commercial size would be difficult. More promising for commercial application are devices utilizing the newer tetrahedral concept.

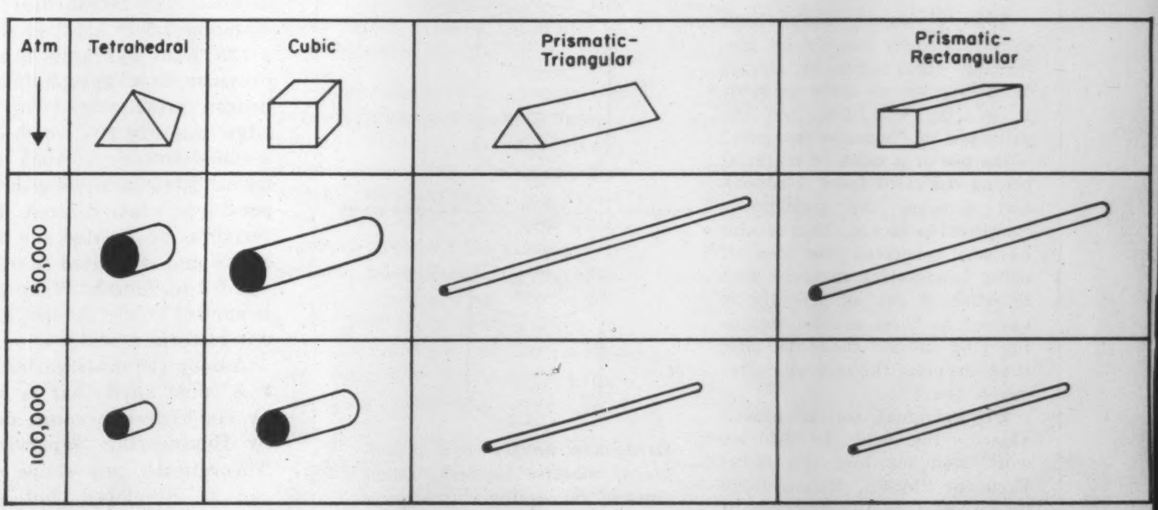
The piston-cylinder concept

Though its future as a production tool appears limited, the piston-cylinder concept developed by Hall (see Fig 9) is the one currently used to manufacture diamond, the only commercial product of high pressure technology.

Known as the "belt" apparatus because of the hardened steel binding rings supporting the carbide anvils, it is a descendant of Bridgman's original piston and anvil. Two conical carboloy pistons, one on each side, thrust into a special carboloy chamber. Pressure is transmitted to the specimen by pyrophyllite in the die. The device used by GE can produce 100,000 atm at 4900 F; with


Hardened steel binding ring
Carboloy semi-piston
Soft steel safety ring
Pyrophyllite
Steel
Pressure cell
Steel
Tantalum
Cooling water
Pyrophyllite
Carboloy
Steel binding ring

9—*Exploded view of the belt apparatus.*
(R. E. Hoffman, et al.)


Atm
Tetrahedral
Cubic
Prismatic-Triangular
Prismatic-Rectangular
50,000
100,000

8—*Size of specimen is related to pressure level and type of apparatus used. Sizes here are based on using 50% of available chamber volume.*
(Engineering Supervision Co.)

some modifications it can reach 160,000 atm at 6300 F.

Because of the military value of man-made diamonds a secrecy lid was clamped on the "belt" apparatus; details were released only a short time ago. Apparently, workers at the Institute for High Pressure Research in Moscow independently developed the same concept since they reported on similar apparatus at the 1960 Conference on Very High Pressure held in Bolton Landing, N. Y.

Secrecy about apparatus plus the knowledge that diamonds had been synthesized catalyzed American scientists to produce many modifications of the piston-cylinder concept. For example:

▶ Dr. A. A. Giardini, of the Army Signal Corps' Research and Development Laboratory, developed a supported piston device that operates in a hydraulic press. His apparatus applies pressures of up to 100,000 atm on a small specimen, 0.5 by 0.4 in., at temperatures up to 5400 F. With it he has made both diamond and Borazon.

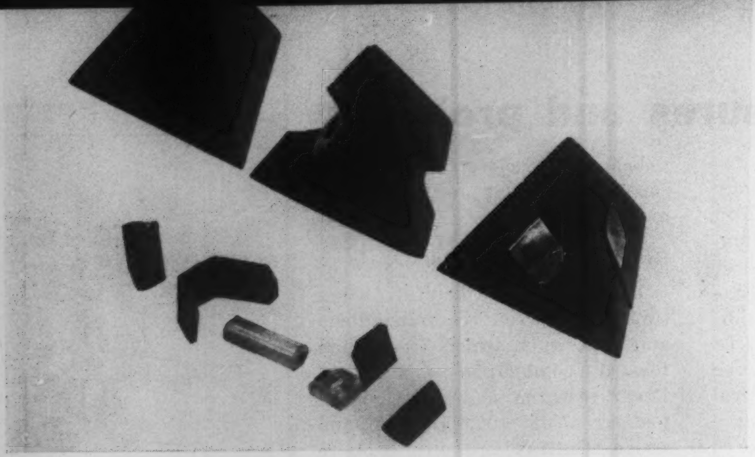
▶ Coes used a piston-cylinder device to synthesize coesite, a dense form of silica. Most geophysicists use a similar device.

The tetrahedral anvil

The tetrahedral concept, also developed by Hall, has served as a starting point for many modifications. A tetrahedral device, standing 7.5 ft high, is shown on *p 110*. Four hydraulic rams apply pressure to a pyrophyllite tetrahedron measuring 1 in. on the edge (see Fig 10) which contains a conductive sleeve that is resistance heated to develop high temperatures when desired. The material to be treated fits into the sleeve and is limited to 0.2-in. dia and 0.7-in. length. When pressure is applied excess pyrophyllite flows out to form a seal.

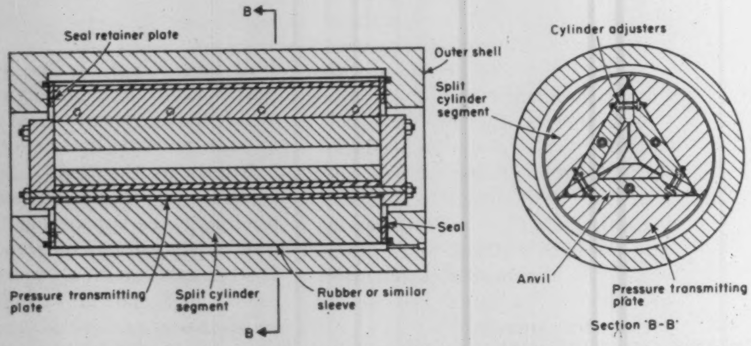
Among the modifications:

▶ A cubic anvil that is squeezed by six hydraulic rams, developed by Engineering Supervision Co. Theoretically any shape of anvil can be developed, but practical problems in positioning make the cube today's geometric limit.



(National Bureau of Standards)

10—*View of pyrophyllite tetrahedron assembly. Note how tetrahedron is machined to allow cylindrical sheath (center foreground) to be inserted. Specimen is inserted in hole in cylinder (0.12 in. dia. 0.2 in. long). Metal tabs on each side of cylinder are electrical leads for resistance heating.*



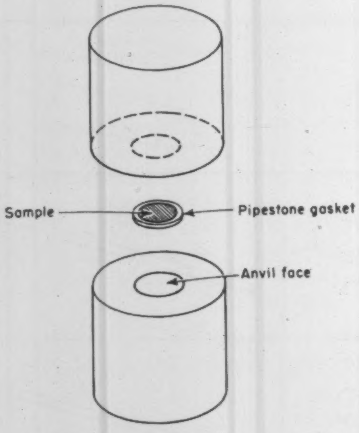
11—*Cross section of prismatic device which can apply up to 100,000, atm pressure on a specimen approximately 6-in. high. Specimens up to 20 in. long may be produced.*

(Engineering Supervision Co.)

Bridgman the Pioneer

Today's research on ultra high pressures rests heavily on pioneering work begun by Dr. P. W. Bridgman as early as 1909. It was he who developed the principle of "massive support"—the use of a mass of material behind the anvil faces to absorb and disperse the tremendous compressive forces. It was also he who conceived the idea of using a gasketing material that is squeezed out as pressure is applied to form a solid retaining ring around the anvil tips, thus keeping the specimen between the dies.

Dr. Bridgman worked almost alone in this field. In 1946 his work won for him the Nobel Prize for Physics. He can truly be regarded as the "father" of high pressure technology.



Bridgman anvils *show principle of massive support. Large mass of supporting ring absorbs pressure generated at anvil face.*

- A hinged, articulated frame, also developed by Engineering Supervision, reduces the floor space required by the tetrahedral device and permits easier alignment of the anvils.
- A radial press that will develop pressures up to 200,000 atm on a 6-cu in. volume. It will be introduced soon by Harwood Engineering Co.

Probably most significant of the modifications, however, is the prismatic anvil developed by Engineering Supervision (see Fig 11). The developers say it will produce pressures up to 100,000 atm on a triangular cross section up to 20 in. long. A rectangular cross section can also be used. Thus, for the first time, long specimens and parts may be feasible.

Measurement problems

It is quite probable that most of the pressures and temperatures that have been reported in connection with high pressure research are in error. The main reason is difficulties in measurement.

Pressure—Fortunately, one major problem of special interest to engineers has been solved: the matter of units. In this article we have used only "atmospheres" ("atm") and occasionally "psi" because these are widely used and easily visualized by engineers. But many other units have been used in the literature. To standardize this area of the field, at least, the 1960 Conference on Very High Pressure voted to adopt "bar" and "kilobar" units exclusively. Table 3 shows how these meteorological units are related to the more familiar engineering units. Note that 1 atm is only 1.3% greater than 1 bar; thus the figure of 100,000 atm mentioned several times in this article is roughly equivalent to 100 kb.

TABLE 3—PRESSURE CONVERSION

Unit ➡ ⬇	Bars	Normal Atm	Kg Per Sq Cm	Psi
1 Bar (10^6 dyne/ sq cm)....	1.	0.9869	1.0197	14.5038
1 Normal Atm......	1.0132	1.	1.0332	14.6960
1 Kg/Sq Cm.	0.9807	0.9678	1.	14.2234
10 Psi......	0.6895	0.6805	0.7031	10.

Source: *Progress In Very High Pressure Research*, John Wiley & Sons, '61, p 314.

The problem in measuring pressure has been to devise a way to measure some reproducible physical property of the solid used as the pressure transmitting medium. Since volume changes are hard to measure, most researchers in this field measure resistance changes. Data based on volume changes above 30 kb are unlikely to agree with data based on resistance changes.

As high pressure is applied to a material, transitions from one phase to another are indicated by abrupt changes in resistance. One such transition point—the 80 kb point for barium—was used for calibration of high pressure devices prior to 1960. Recent work indicates that this transition actually occurs not at 80 kb but at 59 kb. So, much of the early high pressure data is probably in error by about 35% at the 80-kb point. The error decreases as pressure is reduced to 30 kb.

Since definitive standards for measuring pressure have not been developed, today's researchers feel it is important to report exact details of their experiments so that their data can be adjusted and retain its value in the future.

Temperature—The errors in present temperature data have a simple origin: no one really knows how ultra high pressures affect thermocouple materials. Therefore, once a desirable result has been achieved the temperature problem is "solved" by reproducing all conditions of the experiment. The exact temperature remains a matter for conjecture and, hopefully, tomorrow's progress in measurement.

Physical properties—Measuring various physical properties at high pressures by techniques such as x-ray, optical, spectroscopic, etc., presents severe problems that still must be solved.

Acknowledgments

The author would particularly like to thank the following for reviewing the manuscript: Dr. A. A. Giardini, Army Signal Corps Research and Development Laboratory, Dr. W. G. Field, Cambridge Electronic Research Directorate, U. S. Air Force, J. S. Harvey, Manufacturing Laboratories, Inc., Dr. A. Van Valkenburg, National Bureau of Standards, A. Zeitlin, Engineering Supervision Co.

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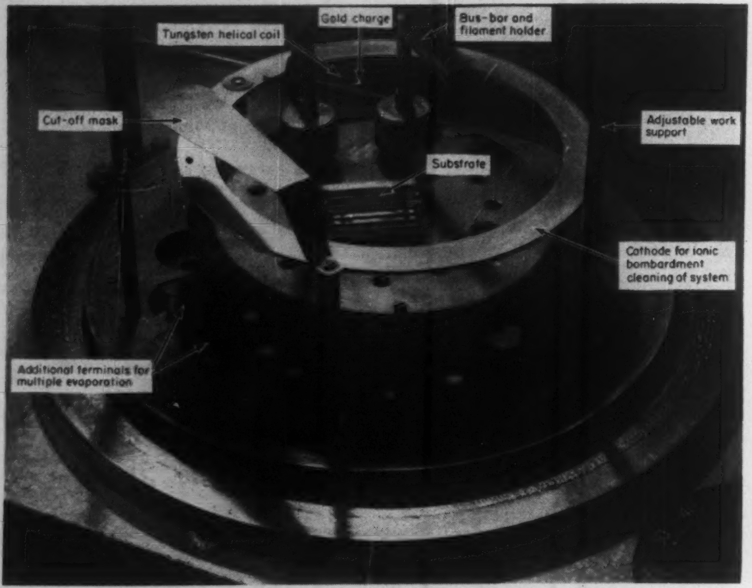
Thin-Film

Parts of many different materials can be produced by vacuum evaporation. Here is an up-to-date report on how this technique is making possible an entire new family of subminiature parts, and thus high density electronic assemblies.


Tungsten helical coil
Gold charge
Bus-bar and filament holder
Cut-off mask
Adjustable work support
Substrate
Cathode for ionic bombardment cleaning of system
Additional terminals for multiple evaporation

1 Evaporator setup *for vacuum depositing pure gold on component substrate.*

■ Ever since the first development of electronics, engineers have been constantly striving to make components smaller and more reliable. This quest has been greatly intensified in recent years because of special space age requirements. In general, microminiaturization can be accomplished in three ways:

1. Radical packaging techniques using standard miniaturized components.
2. Use of molecular electronics to produce a complete circuit on the surface of a single wafer of semiconductor material (see "Tailor-Made Materials Replace Electronic Components," M/DE, Mar '60, p 12).
3. Micromodules using thin-film electronic components and stacked wafers.

In this article we shall confine our attention to the third approach only and show how—through the use of thin films supported by flat wafers—it is now possible to obtain component densities as high as 500,000 components per cu ft.

High vacuum *evaporation is the most effective way to apply a wide variety of thin films for electronic components.*

Thin-film electronic components can be successfully applied to micromodule wafers by: 1) physical methods such as cathode sputtering or high vacuum evaporation; 2) chemical methods such as reduction or electrodeposition; and 3) mechanical methods such as spraying, rolling or silk screening. Of these, high vacuum evaporation (Fig 1) appears to be the most effective and versatile method.

How components are made

Thin-film electronic components are produced by a variation of the vacuum metallizing technique. The desired film metal is heated in a vacuum to a temperature close to its boiling point (see table). The metal vaporizes and is deposited in a prearranged pattern controlled by masking techniques.

The optimum shape and material to use for the heat source depends largely on the boiling point of the charge. Wetting ability and chemical attraction between the charge and filament must also be considered. Naturally, the filament must have a high melting point in comparison with the charge; tungsten and tantalum are commonly used for filaments, although molybdenum is better suited for certain charges. Care must be taken to prevent overheating of the charge because the resulting increased vapor density of the evaporated

Electronic Components

by Arthur F. Menton, *Servo Corporation of America*

metal can cause poor adhesion and film discontinuity.

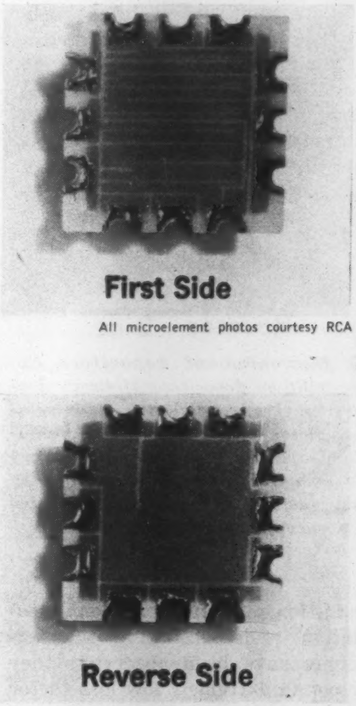
Uniform thickness important

The deposition of uniform films is a challenge and depends on on many factors, such as 1) the materials and shapes used for the substrate, filament and charge, and 2) the right choice of vacuum and temperature. Also, uniform films are difficult to obtain because the substrate is usually flat and the distance of different points on the substrate to the charge source may not be the same. This problem can be minimized by keeping outer dimensions of the substrate as small as possible with respect to the charge-to-substrate distance. Uniformity can also be improved by moving the charge or substrate while evaporation takes place, or by using several charge sources.

Ceramic, glass bases are best

Selection of the proper substrate is important because the substrate material and condition can affect the crystal properties of the active film which is extremely thin (at times less than 100 Angstrom units thick). The best substrates are usually inorganic materials such as ceramics or glass. These should be throughly cleaned and processed to remove gaseous occlusions. An important advantage of these materials is that they are readily available in amorphous form—an important factor in preventing large oriented crystals from developing in the film.

Because of their desirable electrical properties, plastics have been considered as substrate materials. However, they have been ruled out for high vacuum processing because of their high vapor pressure and gaseous impurities.



All microelement photos courtesy RCA

2 Microelement resistor *containing metal film on both sides can be scribed as shown to create two resistor elements per side and to adjust individual elements to desired resistance values.*

Resistors *with exceptional properties can be obtained by depositing thin films of gold-platinum and nickel-chromuim alloys on inorganic substrates.*

Thin-film resistors can be produced by several methods, but one of the most important is vacuum evaporation of noble metals. Exceptional properties (notably thermal characteristics) can be obtained by depositing resistive gold-platinum alloys on glass substrates; these components (Fig 2) are now being produced in large quantities. A typical 60 gold-40 platinum resistive film 100 Angstrom units thick has a temperature coefficient of 0.06% and a resistivity of 190 microhms per in. In general, both the resistivity and temperature coefficient of gold-platinum resistive films can be decreased by increasing the gold content.

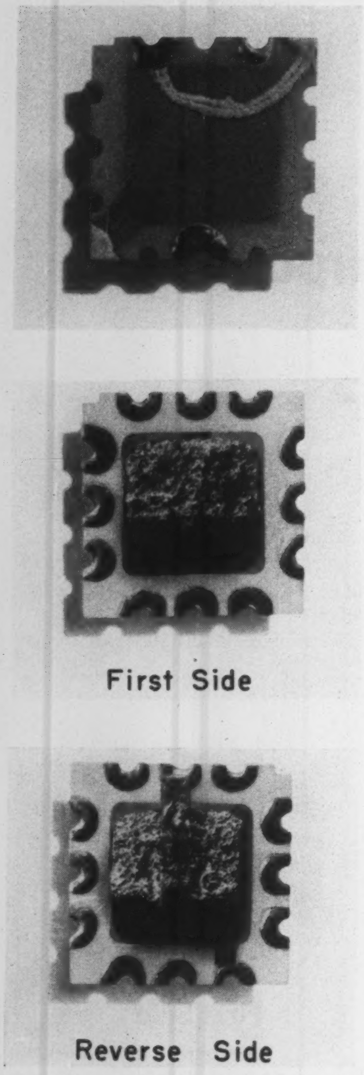
Precision nickel-chromium resistors with resistance tolerances smaller than 1% can also be produced by vacuum evaporation. The film thickness of these components ranges from 1 to 2 μ in and a whole family of resistance ratings—from 10 ohms to 10 megohms—can be obtained without excessive change in film thickness. Recently as many as four individual resistors—two on each side—have been deposited on one alumina wafer. The alloy used is an 80 nickel-20 chromium alloy and is applied by a combination of photographic techniques and vacuum evaporation. Tin oxide film resistors have been applied by similar methods to steatite and glass substrates. Higher resistivity films of metals, oxides, alloys and carbon are being developed using similar base materials.

Capacitors *consisting of many thin-film layers and having capacitance values as high as one microfarad can be made by vacuum deposition.*

Thin-film capacitors are made by first evaporating a dielectric material onto a metallic substrate and then depositing a top layer of metal (Fig 3). The metallic substrate and top layer then act as the electrodes. Values of over 1 μf can be obtained by repeating this process to form a multilayer or stacked-film capacitor. The number of layers used depends on capacitance and voltage requirements, the present practical limit being ten layers. Ceramics are being used as the dielectric, mainly because multiple thin-layer ceramic capacitors have been found to have a fairly constant capacitance over a wide temperature range.

Silicon monoxide has also been examined extensively as a dielectric because of the ease with which it can be vacuum deposited and because of its high conductivity and oxidation resistance. Silicon monoxide capacitors using gold electrode films exhibit excellent insulation resistance, dissipation factor and breakdown voltage characteristics, and high capacitance per unit area. However, the material's promise is tempered somewhat by its relatively poor power factor—40 to 50%.

Aluminum oxide and silicon oxide dielectrics look very promising for thin-film capacitors. In addition to having excellent insulation resistance (100 kilomegohms have been observed) they have an extremely low loss factor and permit capacitance values of 0.032 μf per sq in.

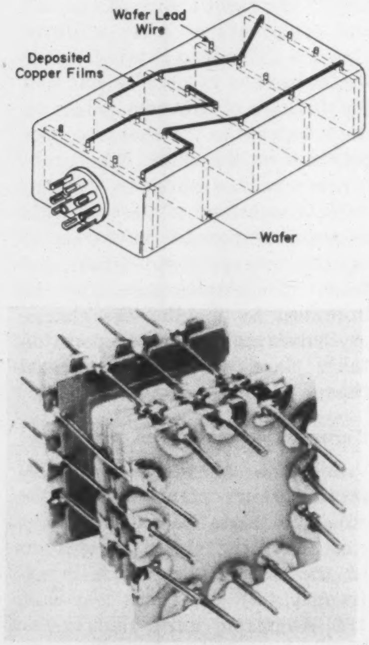


3 Microelement capacitors *can be built by depositing alternate layers of ceramic dielectric and metal conductor (top). Electrolytic tantalum capacitor (two views at bottom) is composed of solid electrolyte in conjunction with tantalum deposited by vacuum evaporation.*

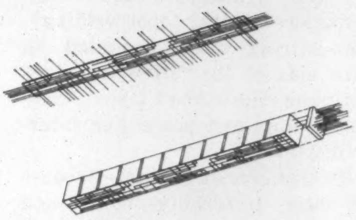
Electrolytic-type capacitors can also be made in wafer form (Fig 3). Capacitors using zirconium, tantalum, aluminum and titanium in conjunction with solid electrolytes have been fabricated successfully. A wide range of capacitance values is obtainable—from 0.1 to 15 μf.

Induction coils *and ferromagnetic storage elements hold much promise for the future, but their development has not kept pace with that of other thin-film components.*

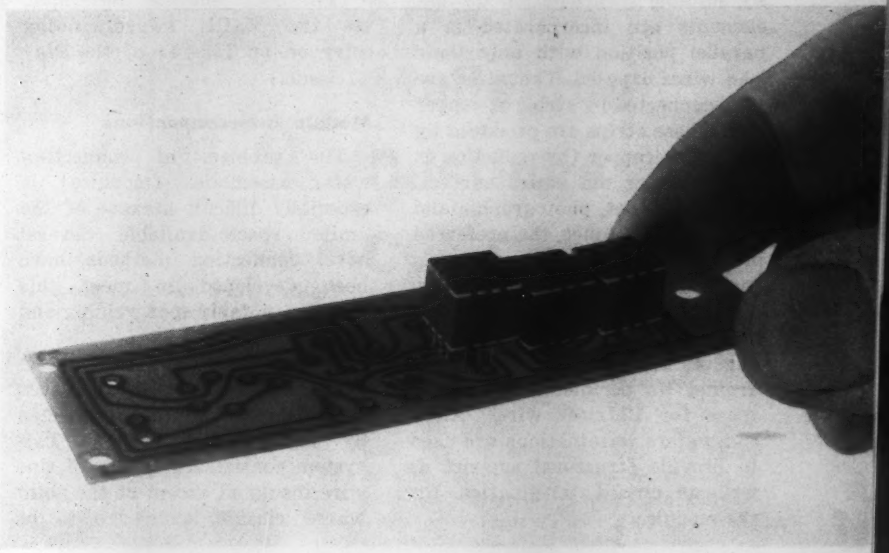
The small size and reproducibility obtainable with vacuum deposits is particularly advantageous in replacing conventional wire wound inductors or transformers. Induction coils can be made by depositing (in conjunction with masking techniques) pure metal on the inside and outside of a ferrite coil which is usually a few hundredths of an inch in diameter. The substrate thickness provides insulation and determines the coupling between the primary and secondary metal



4 Wafers interconnected *by two methods. Interconnection at top is made by using flat copper strips which are deposited on outside of potted module. Interconnection at bottom uses riser wires around periphery of wafers.*



5 Modules interconnected *by two methods. Modules above are connected by "logic wiring" technique in which leads are joined by spot welding. Modules at right are connected by printed circuit incorporating accurately placed holes.*



coils; the shape of the deposited metal (controlled by the mask) governs the inductance. Inductance values as high as 1500 μh have been obtained.

Coils are also made in the form of toroids wound on ferrite cores a few hundredths of an inch in diameter. The toroidal form reduces undesirable coupling to adjacent elements and leakage fields. The coil is usually mounted on one side of a wafer with an organic bonding agent which is also useful as an impregnating material for the toroid. Selection of the best coil impregnant is important because, in addition to having the desired electrical properties, it must withstand thermal shock and resist corrosion and moisture. Inductance values as high as 1500 μh have been obtained.

MATERIALS THAT CAN BE DEPOSITED UNDER HIGH VACUUM

Charge Material ↓	Heat Source and/or Holder for Charge	Evaporation Temp, F
Aluminum	U-shaped tungsten wire or tungsten helical coil	1832
Aluminum Oxide	Tungsten helical coil	3200
Arsenic Trisulfide	Tungsten helical coil	1300
Bismuth	Alumina crucible heated by tungsten conical basket	1290
Cadmium Sulfide	Tungsten helical coil	2550
Chromium	Tungsten conical basket	2270
Copper	Tantalum conical basket	2315
Cryolite	Molybdenum conical basket	1832
Germanium	Alumina thimble heated by molybdenum or tungsten conical basket	2282
Gold	Tungsten helical coil	2670
Indium	Molybdenum or tungsten conical basket	1740
Lead	Alumina crucible	1325
Lead Sulfide	Molybdenum or tantalum conical basket	2335
Nickel	Tungsten helical coil	2750
80% Nickel-20% Iron	Zirconia or alumina crucible	2550
Platinum	Tungsten helical coil	3795
Silica	Beryllium oxide crucible	3140
Silicon Monoxide	Alumina crucible or tantalum conical basket	1832
Silver	Tungsten conical basket or molybdenum helical coil	1918
Silver Chloride	Molybdenum conical basket	1452
Tin	Tantalum conical basket	2170
Zinc Sulfide	Molybdenum conical basket	3450

Considerable headway is being made in developing thin ferromagnetic films which can be used as high speed storage elements, notably for advanced digital computers. Ferromagnetic properties such as the rectangular hysteresis loops necessary for storage elements are being obtained with materials with low anisotropy (e.g., certain nickel-iron alloys) and by depositing films from 500 to 2000 Angstrom units thick. Special evaporating techniques are necessary with the nickel-iron alloys because in the molten state they can affect the high temperature filament materials used for evaporation. Thus, the charge of ferromagnetic material is placed in a crucible instead of directly in contact with the heating element.

Interconnection *of components has always been a major obstacle to obtaining high density electronic equipment. Here are several novel approaches to the problem of interconnecting individual wafers and wafer assemblies. First, wafer interconnections...*

A typical method of interconnecting wafers containing thin-film components is shown in Fig 4.

By suitable encapsulation the flat elements are incorporated in a parallel position with only their lead wires exposed. The wires are then connected by strips of copper film. These strips are produced by depositing copper (by reduction or rolling) over the entire surface. Then, by resist, photographic and masking techniques, the preferred interconnections are made and the excess copper is etched away.

An alternate way of connecting stacked wafers is also shown in Fig 4. Each wafer is notched around its perimeter to provide space for 12 riser wires. Rigid end wafers terminations are used to provide structural support as well as circuit termination for the module.

(For still another technique, see the M/DE award-winning entry on pp 142-144 of the May '61 issue.)

Module interconnections

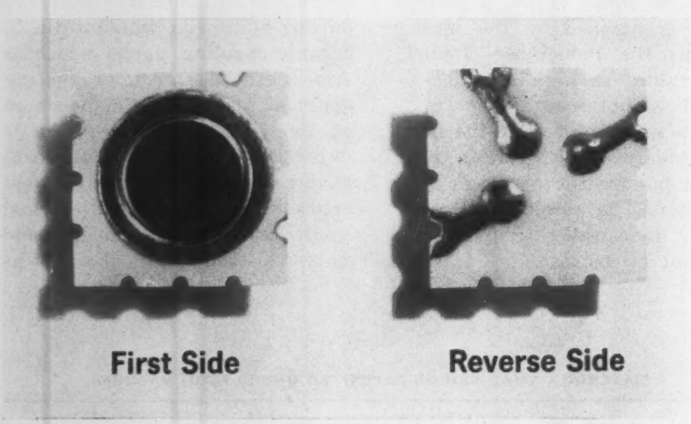
The problem of connecting wafer assemblies (modules) is especially difficult because of the limited space available. Several novel connection methods have been developed to meet this problem, notably spot welding and printed wiring.

Spot welding—In this connection method, modules are placed side by side and then connected by "logic wiring" (Fig 5). This system consists of layers of fine wire insulated except at the point where circuit leads are to be joined by precision stored-energy resistance welding (spot welding). One wiring mesh, mounted on each side of the "stick" provides optimum microcircuit layout, tack-weld joints and power-bus interconnections.

Printed circuit boards—Because of their uniform geometry and terminal lead arrangements, modules can also be assembled on printed circuit boards (Fig 5). By accurate jigging, the terminal leads of each unit can be plugged into carefully positioned holes in the board, and then soldered in place. This connection method is especially advantageous in that it makes for standardized design and easier quality control and maintenance.

Other Components Are Shrinking, Too

In addition to thin-film microelements, related circuit components are now being repackaged in compact forms to aid in the construction of stacked wafer blocks. Special components such as gold-bonded semiconductor diodes, diffused silicon junction diodes, and piezoelectric crystals in the 7 to 70 mc range are now available for stacked wafers. In addition, transistor cases have been made as small as 0.05 in. high by 0.2 in. in dia (see photo) and a newly announced rectangular design measures only 0.125 in. wide, 0.18 in. long, and 0.06 in. high.



Transistor *is tiny enough to be incorporated on alumina wafer.*

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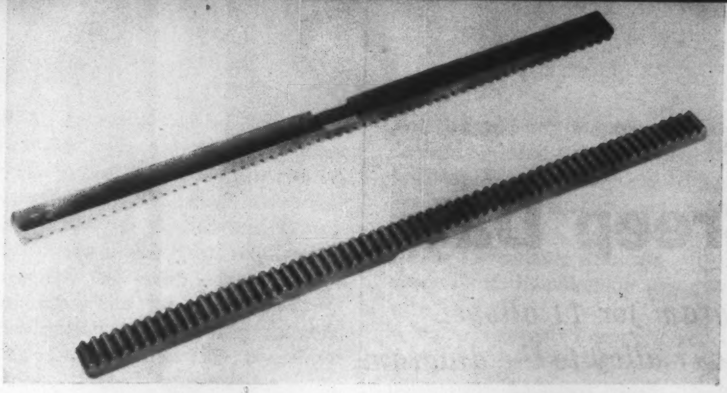
Five Malleable Castings Cut Costs

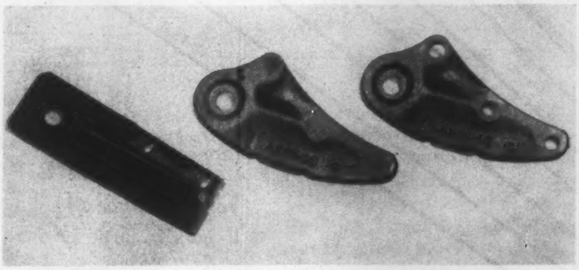


1. Gear rack for boat trailer

These malleable castings are winners in the Malleable Founders Society design contest. Entries were judged on the basis of effective use of cast malleable parts as economical and better versions of machined, forged, rolled or welded parts.

2. Gear and shaft unit

4. Equalizer bar



3. Mounting bracket

5. Cultivator front arm

1 *Gear rack for boat trailer costs 62% less than the previous machined parts. The convex contour on the bottom of the rack and 70 teeth on the top were cast and required no machining. The rack, used to position a boat on the trailer, is automatically stress relieved and will not warp or spring. (First Award: J. A. Heitkamp, Northern Malleable Iron Co., St. Paul, Minn.)*

2 *Gear and shaft unit for an automobile transmission was formerly precision machined from forged steel. Machining costs were cut 19% because pearlitic malleable iron is easier and faster to machine accurately. Malleable is also lighter and costs 29% less than the steel previously used. (Second Award: D. A. Marek, Central Foundry Div., General Motors Corp., Saginaw, Mich.)*

3 *Mounting bracket for an automobile power steering assembly was made of rolled steel bar stock. Previous brackets flexed sufficiently to cause fatigue failure of the mounting bolts. The new design incorporates a protruding ridge that adds stiffness without increasing weight. Cylinder hole and inset, a chamferred edge, and a slightly angled bearing surface are now cast rather than machined. (Third Award: R. A. Johns, Belle City Malleable Iron Co., Racine, Wis.)*

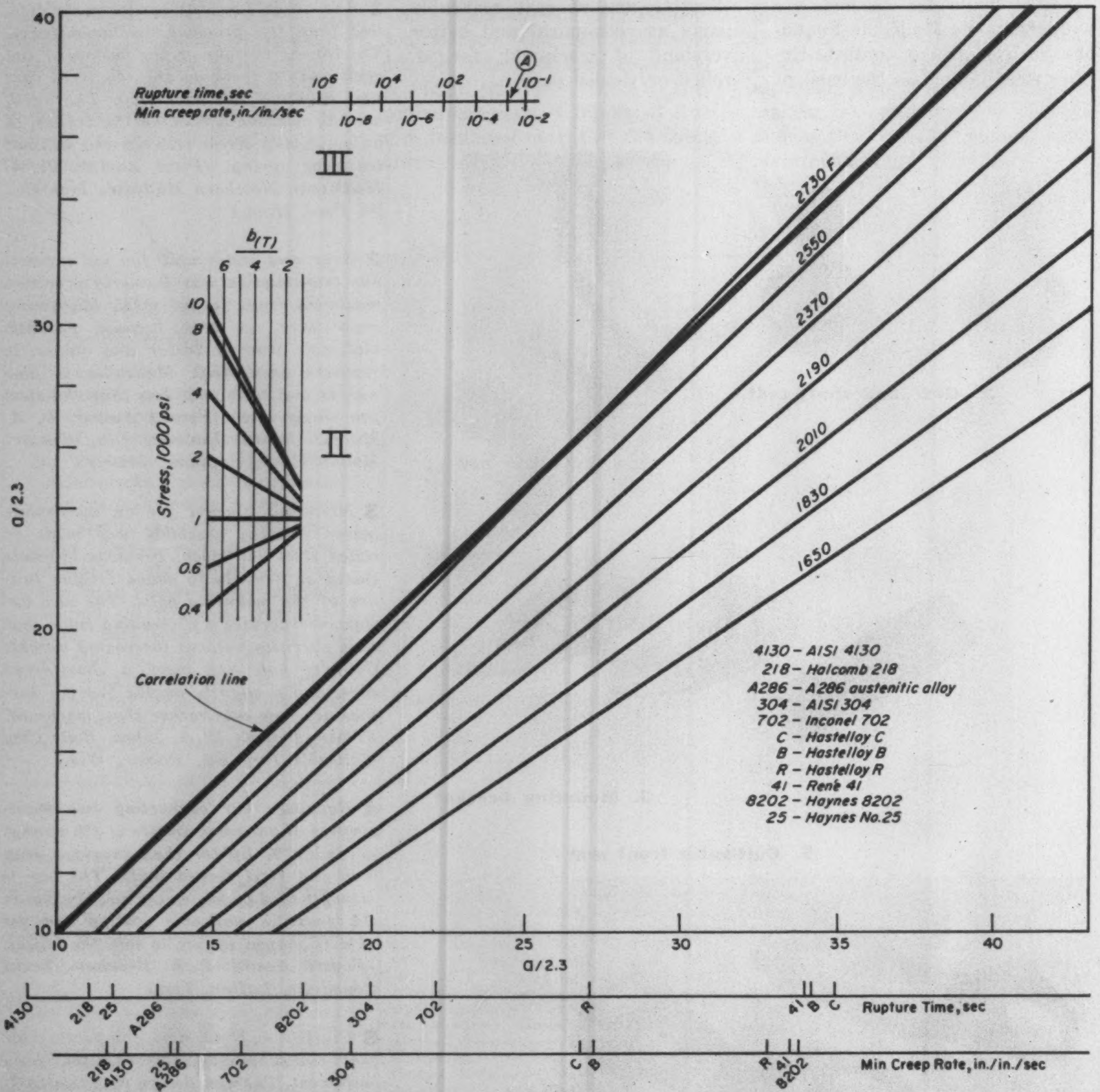
4 *Equalizer bar connecting two mainsprings of a tandem trailer is 8% stronger and 17% lighter than previous gray iron and steel forged units. The bar is strengthened by the stress distribution in the pearlitic malleable casting and use of a U-shaped section to join the bosses. (Fourth Award: J. W. Beckham, Texas Foundries, Lufkin, Tex.)*

5 *Cultivator front arm compactly cast from malleable iron replaced a four-piece weldment. The new design cuts cost 31%, and improves strength and appearance. (Fifth Award: D. Calhan and M. Anglin, Dalton Foundries, Warsaw, Ind.)*

Faster, Less Expensive Creep Data

1. *A master diagram for 11 alloys.*
2. *How to add your alloy to the diagram.*

by Michael Korchynsky, *Metals Research Group, Union Carbide Metals Co.**



1—*Master diagram correlates material, temperature, stress, creep rate and rupture time. The diagram can be used to choose a material that will operate at a given temperature, stress and creep rate. If the material has already been selected, then the creep rate or rupture time can be determined at given stress and temperature levels.*

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* The research leading to these results was supported by the Army Ballistic Missile Agency, Huntsville, Ala.

■ An investigation of the creep-rupture behavior of alloys near their melting temperature has resulted in a method that can reduce creep testing tenfold and drastically reduce the time required to describe the creep behavior of a material. The end result of the investigation is the master diagram, Fig 1 at left, which correlates stress, testing temperature, time to rupture and minimum creep rate for any face-centered cubic iron, nickel or cobalt-base alloy. The equation on which the diagram is based will be discussed later in the article.

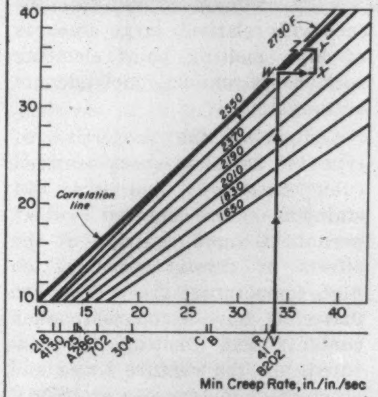
We have plotted 11 alloys on the master diagram. By using the techniques that will be discussed, you can add any number of alloys to those already present. The relationships were developed for creep near the melting point, and the minimum temperature at which the master diagram can be used is a homologous temperature of 0.7.

Materials tested were a representative selection of alloys that encompass a broad spectrum of metallurgical variables: body centered (bcc) and face centered (fcc) cubic structure; presence or absence of an allotropic transformation from ferrite to austenite; varying degrees of saturation of the matrix by solute atoms; and presence or absence of metastable structures.

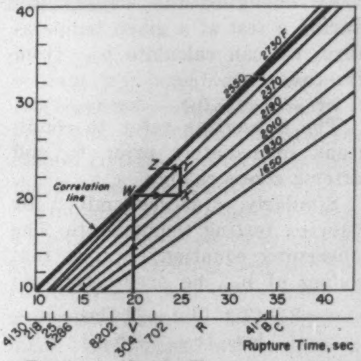
How to use the master diagram

Four variables — temperature, stress, material, and rupture time or creep rate—are plotted in Fig 1. Given any three of the variables, you can easily determine the fourth. The three drawings below show you in detail how to use the master diagram to solve three problems. The first two are the obvious ones of determining either creep rate or rupture time when material, stress and operating temperature are known. Not so obvious is the third problem where you know you need a ma-

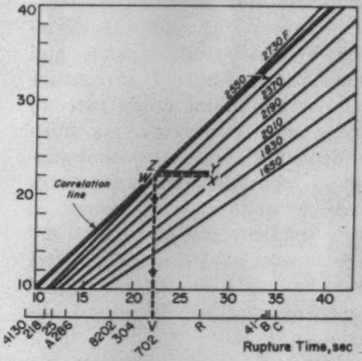
When you want . . .



Minimum creep rate. Known: stress, 4000 psi; temperature, 2370 F; $b_{2370} = 4$; material, René 41. Raise a vertical (VW) from the René 41 point on the minimum creep rate scale (I) to the correlation line and extend a horizontal (WX) to the 2370 F curve. Beginning at this intersection, raise a vertical (XY) whose height is measured on the $b_{(T)}$ vs stress scale (II). At the end of this vertical, draw a horizontal line (YZ) back to the correlation line. This distance represents the minimum creep rate of René 41 at 2370 F and 4000 psi. Lay the length out on the min creep rate scale (III) and read 5×10^{-5} in./in./sec.



Rupture time. Known: stress, 4000 psi; temperature, 2190 F; $b_{2190} = 4.6$; material, 304 stainless steel. Erect a vertical line (VW) to intersect the correlation line from the 304 stainless point on the horizontal rupture time scale (I). Draw a horizontal line (WX) from the point of intersection to the 2190 F curve. At this point, erect a vertical line (XY) whose length is determined by the $b_{(T)}$ vs stress scale (II). From the end of this line draw another horizontal (YZ) to the correlation line. Measure the length of line YZ and lay it out from point A on the rupture time scale (III). Read the time as 80 sec.



An alloy. Known: stress, 1200 psi; temperature, 2155 F; $b_{2155} = 5.4$; rupture time, 2.2×10^5 sec. The procedure is the reverse of that used to determine either creep rate or rupture time. Lay out a box, the top of which (YZ) corresponds to a rupture time of 2.2×10^5 sec measured from point A (see III) and the side (XY) of which is the distance represented on II by 1200 psi and $b_{2155} = 5.4$. Slide corner Z of the box on the correlation line until corner X intersects the 2155 F curve. Draw a horizontal (WX) from the point of intersection to the correlation line and drop a vertical (VW) down to the horizontal rupture time scale. The alloy at this point on the scale (Inconel 702) will meet the requirements.

terial that has a given creep rate at a specified stress and temperature. From Fig 1 you can select a material that meets these design criteria.

Here's how to make your own diagram

To use the diagram for alloys other than those listed, determine $b_{(T)}$ and c by the equations presented in the next section. Calculate a for minimum creep rate and plot points on the ordinate corresponding to $a/2.3$ for the given alloy. Then you are set to use the graphical methods described in Fig. 1.

The basic equation

The equation on which the master diagram is based was developed by statistical analysis and shows the dependence of rupture time or minimum creep rate on stress and temperature as independent variables. A phenomenological approach was necessary since a quantitative theory of high temperature creep has not been developed. Using a computer to fit the data by the method of least squares, we developed the equation:

$$\ln t_r \text{ (or } \ln \epsilon) = a + c/T + b_{(T)} \ln\sigma$$

where t_r = rupture time, minutes
ϵ = minimum creep rate, in./in./sec
T = temperature, K
σ = stress, 1000 psi

a, c = constants
$b_{(T)}$ = a time-dependent parameter
$\ln$ = natural logarithm

This equation provides an extremely high degree of correlation between experimental and predicted data, as Fig 2 shows. Two conclusions can be drawn from Fig 2:

1. Correlations are valid for long test periods except when oxidation becomes a problem (see curve for Hastelloy R).
2. Creep-rupture characteristics of an alloy are not dependent on the method of heating.

The experimental data were obtained in long-duration conventional tests in which specimens were heated either in a furnace or by resistance (some details are given later). Fig 2 shows that by using the equation, data generally can be extrapolated by at least two logarithmic cycles.

Only a few tests needed

The high degree of correlation provided by the equation allows us to significantly reduce the number of tests required for a full appraisal of an alloy's high temperature creep behavior. The minimum creep rate can be determined from as few as four or five tests in which stress or temperature are changed to determine $b_{(T)}$ and c.

By changing the stress level during a test at a given temperature, we can calculate $b_{(T)}$ from the equation:

$$b_{(T)} = \log (\epsilon_1/\epsilon_2) \div \log (\sigma_1/\sigma_2)$$

The subscripts refer to conditions immediately prior to and after a stress change.

Similarly, c is determined by varying testing temperature. The governing equation requires that values of $b_{(T)}$ be predetermined:

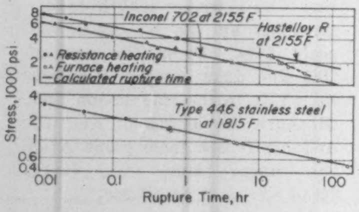
$$c = 2.3\ (T_1)\ (T_2) \div T\ [\log \epsilon_1/\epsilon_2 - \log\sigma\ [b_{(T)1} - b_{(T)2}]$$

With values of $b_{(T)}$ and c, values of a can be calculated from the prediction equation.

Statistical analysis of data from 50 conventional tests showed good agreement when compared with 5 tests performed near the melting point. Note the small differences between values for constants in these equations:

$$\text{5 tests: } \ln \epsilon = 43.8 - (76.5)\ (10^3)/T + b_{(T)} \ln\sigma$$

$$\text{50 tests: } \ln \epsilon = 44.73 - (79.94)\ (10^3)/T + b_{(T)} \ln\sigma$$



2—*Experimentally determined time to rupture for three alloys corresponds well with calculated values. Solid lines represent predicted rupture times.*

Five alloy groups for creep strength

In order of increasing creep strength, the alloys tested can be broadly classified into five groups:

1. Fully ferritic iron-base alloys (type 446 stainless).
2. Austenitic (at testing temperature) iron-base alloys.
3. Nickel-base alloys strengthened with aluminum and titanium.
4. Cobalt-base alloys.
5. Nickel-base alloys strengthened with relatively large amounts of high melting point elements such as chromium, molybdenum or tungsten.

Comparing the properties of type 446 stainless (body-centered cubic structure) and type 304 stainless (face-centered cubic) permits a rapid estimate of the effects of crystal structure on high temperature creep. The two materials have comparable alloy contents and melting temperatures, but the rupture times and creep rates of type 446 at 1870 F are equal to those of type 304 at 2370 F. In terms of homologous temperature (the ratio of testing temperature to melting point), the creep-rupture properties of bcc material at 0.7 are equivalent to those of fcc material at 0.88 of the absolute melting temperature.

These data may be significant in estimating the upper service temperatures of alloys based on refractory metals. If the relationship between bcc and fcc alloys is valid, then the benefits gained by using body-centered cubic metals such as chromium, columbium and molybdenum as base materials may not be as great as the difference in melting points between these and nickel or cobalt-base alloys would suggest.

Silicone Rubber Seals for Atomic Power Reactor

Rotating shield plug *being installed. It is sealed at **1.** The machinery dome is sealed at **2.***

Containment building *seal is extruded from reinforced silicone rubber.*

■ Three large silicone rubber seals, one of them 70 ft in dia, are used in the Enrico Fermi Atomic Power Plant now under construction near Detroit.

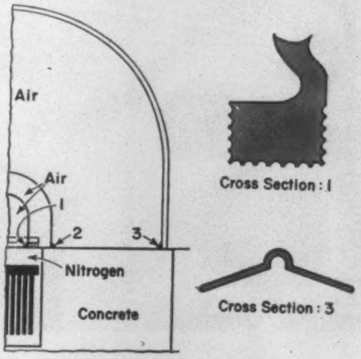
The Fermi breeder reactor uses liquid sodium in the primary loop of the heat exchanger system to power its turbines and generators. Every precaution must be taken to assure that the sodium never contacts air or water. For example, expansion space in the sodium lines is filled with argon.

Silicone rubber was selected for the seals because at the 400 F operating temperature it resists attack by sodium and has a known, controllable permeability to argon and other gases.

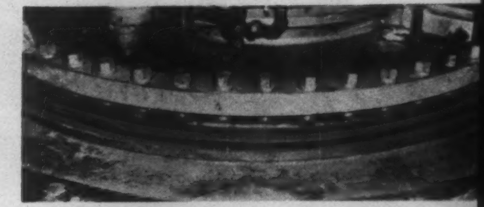
The seals are made from a special compound based on a Union Carbide Corp. masterbatch called KW-1300. They were made by the Detroit Silicone Rubber Corp. in cooperation with Union Carbide's Silicones Div. and Linde Co. after extensive development and design programs.

A 10-ft dia seal around the reactor's rotating plug confines a nitrogen atmosphere below the operating floor, and in emergency would have to confine argon and sodium. The machinery dome over the reactor is sealed with a 20-ft ring, and a 70-ft seal isolates the reactor containment building from the immediate vicinity.

The plug seal is an extrusion, with two feather edges at the top and a bulky bottom section. The reactor vessel seal was molded on a Dacron backing. The containment building seal was molded in sections on Dacron and coated fiberglass.



Section of reactor housing *shows plug seal **1**, machinery dome seal **2**, and containment building seal **3**.*



Sodium pump seal *permits expansion in the hot sodium line. The seal, exposed to argon and molten sodium, is glass-reinforced silicone rubber.*

McDonnell Aircraft Corp.

Mercury spacecraft *and tower as they appear after separation from booster rocket.*

How Materials

■ Of all the scientific challenges faced by man in recent history none has been greater than that of putting an astronaut in orbit and safely returning him to earth. The environment that will be encountered is truly formidable and unlike any yet faced by a man and a vehicle.

In order to cope with this environment engineers and designers have had to operate on the frontiers of knowledge. Yet this has been done with caution. The overwhelming majority of materials used in the Mercury spacecraft have been with us for many years and have a long history of success. And the remaining new and unique materials that are used were selected only after their properties had been demonstrated by thorough evaluation and engineers were convinced that they would successfully meet the test of unusual environments.

Spacecraft materials must be able to withstand temperatures from –100 to over 2000 F, resist fatigue, attenuate noise, and be pressure and water-tight. Furthermore, all materials have to be compatible with hydrogen peroxide—the fuel used for the reaction control system. And all materials used inside the capsule have to be compatible with 100% oxygen as well.

As we shall see from the following, the use of materials in the Mercury spacecraft is a significant step in man's knowledge and will be an important guide in making decisions about future orbiting vehicles and space probes.

by Robert J. Fabian, *Associate Editor, Materials in Design Engineering*

Are Used in the Mercury Capsule

René-41,

a nickel-base superalloy, is used for exterior shingles on the conical portion of the capsule. It will withstand 1650 F heat and fatigue, and resist expected dynamic and acoustical effects.

As shown in the photos on these two pages, the central conical and cylindrical portions of the capsule consist of outer and inner skins separated by a primary structure of longitudinal beams. The inner skin is pressurized to protect the astronaut and his equipment. The outer skin is not pressurized; its primary purpose is to withstand external air pressure loads and to serve as thermal protection for the primary structure.

Since the outer skin is subjected to unusually severe temperatures—as high as 1650 F during reentry — capsule designers were faced with a difficult materials selection problem. Initially, they decided that a cobalt-base superalloy (Haynes Alloy No. 25) would be the best material. However, analysis showed that René-41 nickel-base superalloy provided the best all-around combination of properties for the conical portion of the capsule (as we shall see later, beryllium shingles were selected for the cylindrical portion).

Briefly, René-41 was selected because of its:

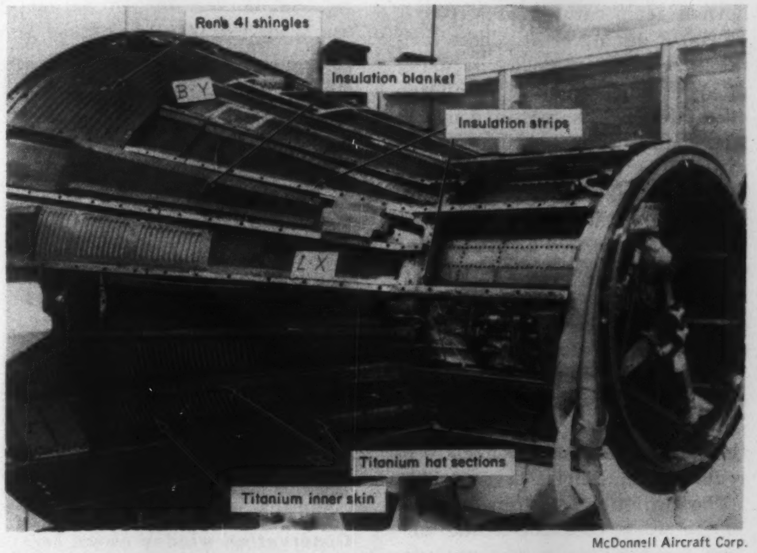
- Superior thermal properties at 1650 F—its ultimate tensile strength is roughly 75,000 psi at this temperature. Also, the alloy has good yield strength and elongation.
- High strength-to-weight ratio.
- High fatigue resistance. This is needed because the outer skin expands and contracts due to local pressure and temperature changes.
- Superior resistance to vibration and acoustic noise effects during launch and reentry.

Since René-41 is a relatively new material, designers initially were not sure if enough material would be available. However, this situation improved when a number of companies such as General Electric, Haynes Stellite (Haynes Alloy R-41), Cannon-Muskegon and Kelsey-Hayes started production of this alloy.

After choosing René-41, designers then had to decide what configuration of the material would best meet the intended end functions. An envelope of rectangular shingles was selected because this design can accommodate relatively large dimensional changes. The edges of each shingle contain large holes and are mechanically fastened with oversize washers to the longitudinal stringers to allow for thermal expansion.

Because the shingles are not designed to carry any high loads their thickness was held to 0.016 in. However, for added strength each shingle is fabricated with parallel indentations (see photos) resembling a washboard surface. No forming problems were encountered during fabrication at McDonnell Aircraft Corp. Some early problems developed because of lack of cleaning prior to heat treatment, but they were overcome when proper precautions were taken.

Designers were fortunate in that they could combine normal heat treatment steps with a black oxide coating treatment. The thermal characteristics of the black oxide coating are instrumental in controlling surface temperature during thermal cycling.



McDonnell Aircraft Corp.

***Structure of capsule** is a wedding of old and new concepts. Conical portion will be completely covered with outer skin of René-41 shingles; cylindrical structure (right) will be covered with beryllium shingles. Not shown is large titanium ring which will fit at base (left) to attach heat shield to capsule.*

The combined treatment:

1. Heating to very high temperature (roughly 2000 F).
2. Holding for 1 hr and then cooling rapidly.
3. Reheating for 16 hr at about 1500 F until the desired mechanical properties are obtained.

This treatment produces a black oxide coating on both sides of the shingle. A high temperature black ceramic paint is used for touch-up; however, its properties are not as good as those of the original black oxide coating.

Special insulation

will be used at critical points to protect the astronaut and equipment over a temperature range of -100 to over 2000 F.

Because of the wide temperature extremes that are concountered it is extremely important that the capsule be well insulated. In addition to resisting high heat, the insulation must have maximum efficiency (a low k factor) and minimum weight.

The conical portion of the capsule containing the astronaut reaches a maximum temperature of 850 F during launching and 1650 F during reentry, as well as normal temperatures of —100 F to 200 F during orbit. These temperatures are controlled by using a ¼-in. thick blanket insulation (see cutaway photo) in conjunction with a cabin auxiliary heating and water evaporation cooling system. This insulation is composed of resin-bonded ceramic fibers enclosed in a glass fiber fabric and is bonded to the outside of the inner skin with an epoxy adhesive. Originally, the capsule was designed to incorporate 1¼ in. of insulation; however, thickness was later cut to ¼ in. when experience showed that the insulation is more effective at reduced atmospheric pressures.

The insulation is designed so that in the worst case the inside surface temperature on the pressurized compartment is 170 or 180 F. It also provides high noise attenuation, thus protecting the astronaut from the high noise generated during launching and by boundary layer turbulence.

Insulation is also required at the 24 structural ribs that separate the inner and outer skins. Min-K insulation encased in stainless steel foil is used between the outer skin and the ribs to prevent a through thermal path and cut heat flow to the inner skin. Min-K (a proprietary insulation) has a thermal conductivity considerably lower than still air. Its low thermal conductivity (only 0.2 Btu/in./hr/sq ft/°F at 1000 F and an equivalent altitude of 60,000 ft) enables it to provide the needed thermal protection in extremely thin, lightweight sections.

Foil-encased Min-K insulation is also used on critical sections of metal tubing in the reaction control system and on the two hydrogen peroxide reaction control storage tanks located at the base of the capsule directly behind the heat shield.

In capsules using an ablative-type heat shield an additional ¼-in. layer of Min-K will be epoxy-bonded directly to the back of the shield in the area of the storage tanks. The remaining central area of the heat shield will be covered with a 1-in. thick layer of the resin-bonded ceramic fiber insulation described earlier. This insulation is heated to 600 F prior to cementing to burn off the integral binder. This is done to allow the insulation to absorb water and provide added weight for stability when the capsule lands in the ocean.

The durability of these insulation systems under abnormal conditions was demonstrated successfully during the firing of an unmanned capsule into space in February. At no time did the temperature inside the capsule exceed 90 F.

Corning Glass Works

***Observation window** shown here in mockup contains outer panes of 96% silica and inner panes of aluminosilicate glass which will accommodate a temperature difference of 1000°F.*

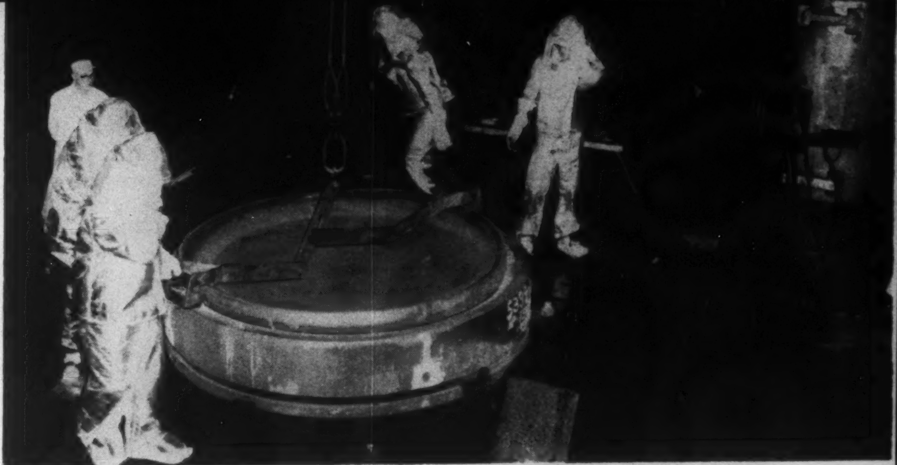
Glass

used for the astronaut's window and antenna shields must provide good optical clarity and electrical characteristics, as well as resist high temperatures.

By looking out of the window the astronaut is able to determine the capsule's attitude and to make astronomical observations (including photographs). These visual requirements plus the high temperatures and rugged mechanical environments that are encountered called for ingenuity in materials selection.

Some capsules have an 8½-in. circular viewport (see photo) containing an outer assembly of three panes of 96% silica glass and an inner assembly of two tempered aluminosilicate panes. In order to give the astronaut better vision other capsules use a larger, trapezoidal viewport design: This design incorporates two outer panes of 96% silica glass and two inner panes of tempered aluminosilicate glass. Its maximum height is 21 in.; width is 7½ in. at the top and 11 in. at the bottom. Each piece of glass is ground and polished to a precision finish to provide high optical quality.

In both designs 96% silica glass was selected for the outer panes to withstand the high temperatures and thermal shock that are encountered in launch and reentry.



Brush Beryllium Corp.

Beryllium heat sink *being forged here will be used on some ballistic flights. Later vehicles, both manned and unmanned, will use an ablative-type shield to protect the structure from the tremendous heat generated during reentry.*

In addition to resisting heat the glass acts as a heat sink (the dead air spaces between the panes also improve insulation). The inner tempered panes were selected to prevent loss of cabin pressure, keep water out of the capsule when it lands in the ocean, and to withstand medium range temperatures. In the event that the outer pane should be damaged the remaining 96% silica glass pane and the inner pane assembly are capable of withstanding all environments.

Temperature is expected to vary across the entire pane assembly from 1200 F at the outside to roughly 70 F at the inside. The outer panes are sealed in an aluminum silicate fiber insulation, and the inner panes are sealed in silicone rubber to provide a combination of heat resistance and water sealing.

Heat resistant glass is also needed to protect the capsule's highly important radio antennas. The glass shield for these antennas (shown in the photograph on p 128 as the dark circular band above the cylindrical portion) is made of 96% silica glass, selected for its resistance to breakage and its stable electrical characteristics under sudden and extreme temperature changes.

The sections are made by:

1. Grinding blank pieces of glass to the required thickness.
2. Sagging the sections under heat to the precise curvature needed.
3. Cutting the sections to size —⅛ in. thick by 6½ in. high.
4. Treating sections in a special acid bath to improve their strength.

Titanium

was selected for the primary structure of the capsule, including the pressurized inner skin. It provides the desired strength and light weight and withstands the maximum expected temperature of 900 F.

Commercially pure titanium was selected for the inner skin of the capsule because designers had to have a lightweight material with usable strength up to 900 F. Titanium proved to be the most efficient material under the expected conditions of tension and compression. Furthermore, because of its weldability it could be made pressure-tight to accommodate the large pressure differential between the pressurized interior of the capsule and the high vacuum prevailing outside.

The skin is made of eight segments which are joined by fusion butt welding. Although the material is amenable to cold forming and beading operations, these are usually done in the hot state to avoid residual stresses.

The titanium inner skin is welded to the hat-shaped stringers which are made of A-110AT titanium alloy (5 aluminum–2.5% tin). This medium strength alloy was selected for several important reasons:

- Usable strength up to 1000 F and good oxidation resistance up to 1200 F.
- Fatigue endurance limit of about 60% of its ultimate tensile strength of 125,000 psi. In this and other respects it provides better mechanical properties than commercially pure titanium.
- Formability (including hot forming) into desired shapes without difficulty.
- Excellent weldability.

Another unique application for titanium is the ring used to join the bottom conical section of the capsule to the heat shield. This ring is the largest-diameter welded titanium ring yet produced. It is 74 in. in dia, 2.875 in. thick, and has a face width of 1.85 in.

Beryllium

will be used on two important exterior structures because of its ideal combination of a high melting point and excellent heat absorption.

Because of its non-uniform contour and its changing attitude during flight the surface of the capsule is subject to a wide range of high temperatures. As the capsule reenters the earth's atmosphere the temperature at the heat shield climbs well over 2000 F and the surface temperatures of the conical and cylindrical portions reach maximums of 1650 and 1300 F, respectively. If René-41 were used on the cylindrical section, temperatures above the melting point would be reached unless a thicker skin were used. Thus, each outer section of the capsule presents different materials selection problems.

After analyzing the temperature control required on the cylindrical portion of the capsule, designers decided that beryllium would best serve their requirements. Beryllium shingles not only withstand the high heat generated at the surface but also act as a heat sink to reduce temperatures to the point where conventional materials (e.g., aluminum and magnesium) can be used for the interior. Because of their heat sink function the beryllium shingles are considerably thicker —0.22 in. total —than the René-41 shingles.

McDonnell receives the shingles already fabricated from the materials producer and applies a black oxide coating on the outside and a gold coating on the inside for heat control purposes. The four-step coating operation consists of:

1. Cleaning.
2. Chemical polishing.
3. Anodizing to produce a black oxide coating.
4. Applying a gold conversion coating to interior surfaces and heating it so that it bonds. This coating provides necessary emissivity and heat control properties.

Because of its good combination of thermal properties beryllium was also selected for the large circular heat sink to be used on the bottom of some capsules that have ballistic trajectories. In addition to its high melting point (2345 F) beryllium has a high specific heat (0.46 Btu/lb/°F at room temperature) and is much lighter than aluminum, steel or copper.

The beryllium heat sink is one of the largest pieces of metal ever produced by powder metallurgy techniques. After hot pressing, the billet is approximately 58 in. in dia by 8 in. thick. It is then sized down to 54 in. by 6 in. for the forging operation. Forging (see photo) increases its diameter to 80 in. and reduces thickness to 3 in. At this point the billet is ready for machining to final dimensions—74 in. in dia by 1 in. thick. Final weight is 350 lb—half the weight of aluminum and one-fifth the weight of copper that would be required to provide equal heat absorption.

Actually, the beryllium heat sink will be used only on some capsules carried aloft by Redstone boosters. Firings with manned capsules will be made with Atlas boosters and because of the higher speeds and temperatures involved will use an ablative glass-fiber-reinforced phenolic-silicone heat shield which is expected to provide better heat control.

Plastics

plus an aluminum honeycomb core are combined in a rigid, composite couch structure that will carry the astronaut in safety and comfort.

Because of the rigors of the space flight the astronaut's couch seat has to provide the highest degree of safety and comfort. In meeting these requirements engineers had to strike a balance between:

▶ Custom-tailoring the couch for the astronaut.

▶ Making the couch strong, yet light in weight.

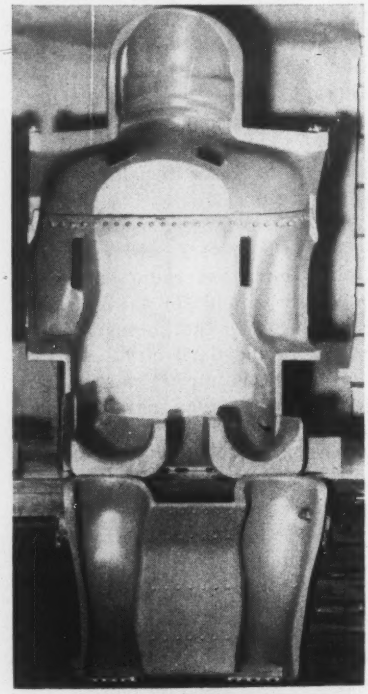
▶ Using materials and fabrication processes that would provide the highest reproducibility and reliability.

From these factors, engineers concluded that a composite structure of plastics and metal would best serve the astronaut and the mission. As shown in the photos the final design is quite unique and consists of a laminated structure made up of outer layers of glass-reinforced polyester and an inner core of aluminum honeycomb plus cast plastics inserts and adhesive. The entire structure is cured simultaneously by bag molding.

Aluminum honeycomb was selected for the core because of its high rigidity-to-weight ratio. Core density is varied at different points to accommodate stress load variations. Glass-polyester is used for the skins because of its ability to be tailored to complex shapes and because of its high strength-to-weight ratio.

The filled epoxy inserts used with the aluminum honeycomb core were selected for their ability to receive and transmit loads around corners and because they eliminated the need for difficult machining of the core. The adhesive that binds the components together is a modified epoxy supported in a glass carrier. This material was chosen for its good binding properties, uniformity and ease of application.

The design also incorporates two thigh supports and a leg support which are hinged to the main couch structure. The thigh supports are made of chem-milled magnesium. The leg support (see detail) is an externally stiffened, glass-polyester laminate.



McDonnell Aircraft Corp.

Composite seat structure *(top) contains an inner structural core of aluminum honeycomb set between structural layers of glass reinforced polyesters. Detail at bottom shows glass-polyester thigh support; the end is hinged for attachment to basic shell.*

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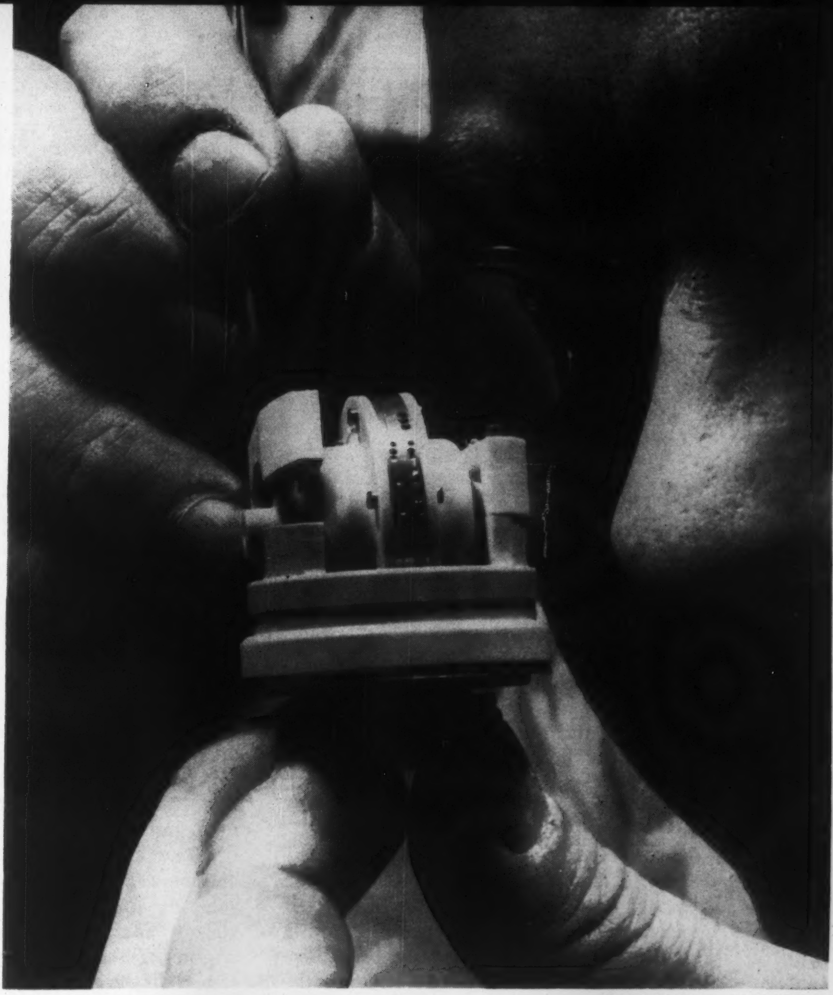


Gyroscope motor of alumina ceramic won an M/DE Award of Merit this year.

Minneapolis-Honeywell Regulator Co.

The Future for Ceramics

by Malcolm W. Riley,
Associate Editor, Materials in Design Engineering

An important change is taking place in ceramics. They are emerging from such specialized uses as electrical and electronic parts, furnace refractories and plumbing fixtures to become structural engineering materials of broad usefulness. But major problems remain to be solved.

Here is what the experts say you can expect of structural ceramics in the years just ahead.

"Future ceramic materials for high performance structural applications will be developed from the atom up, much as some of our electronic materials are today . . ." —J. R. Tinklepaugh, College of Ceramics, Alfred University.

■ The future of ceramics is secure in electrical and electronic uses, furnace and crucible lining applications, and other uses where their performance has been proved and the materials are understood. The biggest question mark in the future of ceramics is their use in structural, load-bearing applications.

Even in load-bearing uses few problems exist if the component can be easily designed so that the ceramic is loaded primarily in compression. For example, valve seats and abrasive nozzle liners have been used without problems.

But an increasing number of engineers and designers have been forced to turn from more conventional structural engineering materials to ceramics to meet critical operating conditions: ultra high temperatures, severe corrosive conditions, unusual optical demands. Parts such as radomes, missile nose cones, high temperature piping and pipe fittings, to mention just a few, may not be amenable to designing for such a simplified stress situation.

Already complex structures such as ceramic springs and high temperature tongs have been designed. Sometimes the results of such design are exciting . . . too often disappointing. It is this problematic future—the future of structural, load-bearing ceramics—with which this report is primarily concerned.

The problem is large . . .

To many encountering ceramic materials for the first time, the engineering and design data available appear meager and uncommunicative, the variety of materials confusing, the design approach highly empirical. This impression has led many to believe that ceramic engineering has lagged far behind the technology of other materials, notably metals. There are three main reasons for this impression:

First, as L. H. Van Vlack, of the University of Michigan, points out, "Ceramics are more complicated than metals and it is therefore not surprising that fewer details are known about their basic nature than are known about metals."

Second, the ceramic materials industry has been highly product-oriented, i.e., oriented toward structural clay products, refractories, electronics, white wares, etc. Within each product area specialized engineering information has been developed according to need.

Third, engineers and designers unfamiliar with ceramics do not understand the behavior of ceramic materials. Ceramics behave differently than metals. They fail in brittle rather than ductile fashion. Consequently the design approach used for ductile materials is invalid.

On this problem *M. G. Britton*, of Corning Glass Works, has said, "Because mechanical properties of metals have been so intensively researched, measured, catalogued and projected into successful designs by means of thoroughly tested design principles, there is a tendency to do the same thing with brittle materials. Nothing could be more futile. Every design prediction based on published ceramic properties must be questioned until thoroughly proof-tested because test methods, specimens, and design concepts are subject to as yet unpredictable variations which force us to use a statistical approach."

. . . but the future is bright

On the other hand, a number of factors indicate that these basic problems are being solved and that the future is bright.

- According to Van Vlack, ceramic science is developing rapidly. Actually, there has been considerable scientific knowledge developed in the past within each specialized field of ceramics, e.g., phase relationships and crystal structures of furnace refractory materials have been well understood for a long time, even in complicated compositions involving three, four, five and six components. Also, a great deal of progress has been made in the piezoelectric and magnetic ceramics. There are now strong indications that these various specialized areas of ceramics are gradually merging to form a more unified materials science.
- Ability to vary and control ingredients in ceramic compositions has been radically improved by progress in generating and controlling the high temperatures necessary for processing ceramics. In fact, according to one ceramist, "In terms of variety and type of materials available, ceramics today are at the stage of organic plastics ten years ago."
- The large amount of ceramic work being done by end users, such as the aerospace engineers, in developing specific hardware (e.g., nose cones, fins and rocket nozzles) is familiarizing more and more engineers and designers with the unique characteristics of ceramics. At the same time engineering principles are now being increasingly applied to the solution of ceramic problems; thus ceramics people are now talking the language of the engineer.
- Finally, a multitude of specific new ceramic materials—some commercial, some developmental—have been announced within the last few years. Among them: 1) translucent, ultra high alumina and magnesia ceramics with density approaching the theoretical, 2) pyrolytic and recrystallized graphites, as well as graphite textiles, 3) glass ceramics, produced by crystallizing glass, 4) cellular or foamed ceramics of many types, 5) special high temperature ceramic materials of a virtually endless variety, and 6) several ceramic fibers. These are only a few, and do not even touch on the work in electrical and electronic ceramic materials.

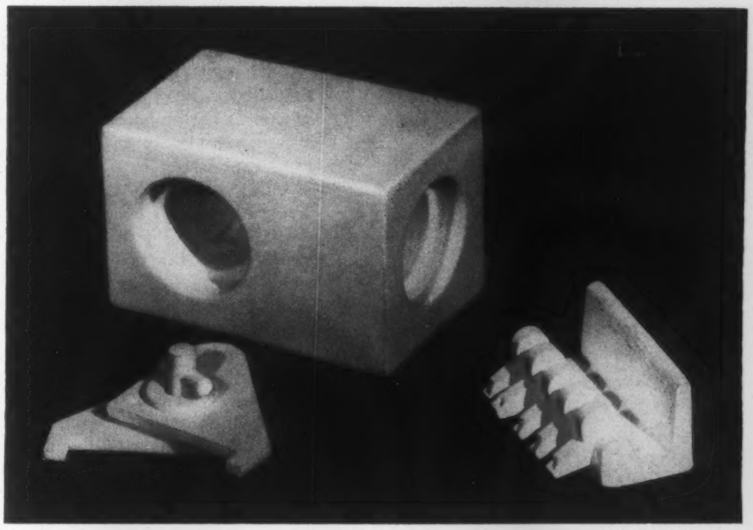
But what will all this mean to you—the engineer, the designer, the materials man? What can you expect in the future?

1. Broadly speaking, you can look for the growth of a unified field of ceramic engineering materials, ultimately merged with a broader materials engineering field. (The rapid development of an interdisciplinary approach in ceramics and what it may mean to engineers is discussed in the box on p 136.)

2. More specifically, you can expect the development of materials with more reliable, more reproducible, and more predictable performance capabilities.

Materials: improved performance, new approaches

It would be impossible to cover all new and promising developments in performance of ceramic materials in this space. But probable the most indicative and pertinent investigations are those aimed at 1) improving ductility or shock resistance, 2) improving strength and reliability, and 3) producing composite materials "systems" that can provide improvements in various performance characteristics as well as ease of fabrication.



American Lava Corp.

High production *processes such as multicavity injection molding, can lower costs and improve design possibilities for ceramics.*

A realistic look at 'ductile ceramics'

Brittleness is as inherent in ceramics as ductility is in metals. This has often come as a shock to the metals-oriented engineer attempting to apply ductile design concepts to ceramics. Much widely publicized work has been directed at increasing the inherent ductility of ceramic bodies, but there is little agreement among ceramic engineers and researchers as to the prospects of success.

What researchers think

"Although it is futile to anticipate that ceramics can compete with metals on a ductility basis alone," according to Van Vlack, "even the slightest increase in ductility could provide major differences in the tensile strength of ceramics because stress concentrations at the end of microcracks would be significantly reduced. For example, if the radius of curvature at the base of a crack is increased from one to two atomic diameters stress concentration is reduced by a factor of the square root of two. In these terms, slight additional ductility can gain engineering importance."

A similar view is held by J. M. Neff, of Armour Research Foundation: "We may eventually get to some point where we can get slippage of planes of the crystal, which may compensate to a certain degree for the brittleness of ceramics. . . ."

"But," he adds, "ceramic materials will always be brittle as long as they are fundamentally ceramic materials."

C. G. Harman, of Gladding, McBean & Co., is dubious about this direction. Although such investigations have added to the store of academic knowledge and thus are worthwhile, nothing of engineering importance is anticipated, he says. In seeking materials for special purposes, Harman says, some work is realistic and some is not. "A large effort is now directed toward development of ductile ceramics, but no corresponding effort to develop optically transparent steel."

And J. R. Tinklepaugh, of Alfred University, is not alone in fearing that "if and when the ductile ceramic work is extended to polycrystalline materials, we will find that in creating ductility we have lost the high temperature strength properties we liked in the ceramic in the first place."

On the other hand, *W. H. Duckworth*, of Battelle Memorial Institute, believes that "means of preparing ceramics with altered microstructures offer the potential for improved strengths and, as brittleness is not necessarily inherent, could give us practical ceramics that are ductile."

Fundamental work is useful

Regardless of the outcome, most researchers would agree that any fundamental work that adds to an understanding of the materials is useful.

Probably the most widely discussed (and publicized) work has been that done at the University of California, primarily on single crystals of such ionic materials as magnesia which display ductility in single crystal form and when loaded at a relatively slow rate. The applicability of this phenomenon to polycrystalline bodies is moot.

The California studies are being extended to polycrystalline materials, the first being extruded rods of lithium fluoride. But the attendant publicity may have resulted in some misguided optimism among engineers. The researchers themselves emphasize that such work is highly preliminary, and that ductile ceramics, should they be developed at all, are a long way off.

Nonetheless, the investigations are providing basic information

"It is only in recent years that engineering has been applied to the solution of problems in ceramics."

—William C. Stetson, Vice President and Chief Ceramic Engineer, Saxonburg Ceramics, Inc.

on how to handle such materials, what characteristics are necessary for ductility, and what properties control ductility.

Systems approach promising

Another, more expedient approach has been that of combining ceramic materials with ductile materials to form a hopefully ductile composite—an example of the so-called systems approach. Much of this work has been done by engineers and designers attempting to develop specific hardware.

Two techniques have been used. The first is combining a metal binder phase with a ceramic phase during sintering, thus producing a so-called "cermet." The second is combining discrete forms of metals (e.g., honeycomb, sheet or fibers) with the ceramic to form a mechanical composite.

Success in substantially improving ductility or impact strength has been quite limited. On the other hand, such work has resulted in some startlingly successful improvements in other properties such as thermal shock resistance, abrasion resistance and strengtn, as discussed later.

Greater strengths can be expected

Regardless of the prospects for developing ceramics that fail in a ductile fashion, increasing their strength is certainly desirable. Substantial progress has already been made, as indicated by the development of dense, high alumina (99+%) ceramics with tensile strengths on the order of 39,000 psi; and development of recrystallized graphites with bulk strengths on the order of 10,000-12,000 psi, as compared with 1000-1500 psi for engineering sizes of conventional graphite.

On the other hand, judging from molecular bond strength, strengths of ceramics (as well as metals) should be in the millions of pounds per square inch. But, according to A. A. Griffith's widely held flaw theory of fracture: flaws within the bulk or on the surfaces of the material tend to

The Interdisciplinary Approach and What It Means

Perhaps in no other materials field is the interdisciplinary approach being embraced so rapidly and completely as in the field of ceramics.

Until relatively recently the long history of ceramics was written by the potter, the processor, the fabricator. He has now been joined by the solid state physicist or materials scientist, as demonstrated by developments in molecular engineering of ceramic solid state electronic devices. He has also been joined by the engineer and designer, as demonstrated by development of ceramic missile nose cones and radomes.

This trend has been discussed by W. H. Duckworth, of Battelle Memorial Institute, writing in *Ceramic Age*. Speaking of the basic sciences, Duckworth says: " . . . new scientific disciplines and tools have been introduced to ceramics at an increasing rate. The specialized knowledge and tools of solid state physics, chemistry, mechanical metallurgy, mechanics, radiation physics, chemical thermodynamics and other of the less applied scientific disciplines are being more actively engaged in ceramic research."

Speaking of applications research, Duckworth says: "Research to bring about new uses for ceramics has also required an interdisciplinary approach. Such an approach involves engineers or technologists who understand the conditions of service as well as those who understand how to modify existing ceramics or how to develop new ones that meet the requirements of the new use."

What will be significant to the end user in this merging of disciplines is the welding of the entire field of application of ceramic materials into a unified, rational science. Ultimately ceramic application will no longer rest on empiricism, but will be based on a fuller understanding of the relationship between basic structure and performance, which will make it possible to predict the performance of a given structure.

The future for tailor-made ceramics

An understanding of the relationship between structure and performance is the first step toward "engineering" a structure to provide a desired type of performance, i.e., molecular engineering. This approach has proved its practicality in the electronic materials field.

The motivation for such an approach exists. As *Duckworth* points out, " . . . by and large it is a lot easier to market a material developed for a specific use than to have a new material and try to find what it is good for. . . . Certainly there is a better chance of success (with this approach) than in taking a new material to the end user and asking 'What can we do with this stuff?' "

But the development of a basic knowledge of structure sufficient to produce such materials is still far off.

Some workers are quite optimistic. For example, C. G. Harman, of Gladding, McBean & Co. feels that in the near future appropriate portions of previous exploratory research will be completed and correlated to yield a sound basis for a reliable relation between basic structure and performance.

Harman feels that the work will establish the predominant and secondary parameters that control mechanical, dielectric, and erosion and corrosion characteristics, as well as age-stability. Initially, of course, some properties will only be predictable in an approximate manner, e.g., those sensitive to impurities and impurity centers, and to spurious factors caused by poorly understood electronic, magnetic and radiation effects.

But the direction has been established. As J. R. Tinklepaugh, of Alfred University, says, "Future high performance structural ceramics will be developed from the atom up."

concentrate applied stresses; as stressing proceeds, a critical condition is reached in a small volume that causes a submicroscopic crack to propagate spontaneously. Thus the theoretical strength of the material is reached only locally.

To improve the strengths of ceramics, the important thing, according to *Duckworth and Rudnick,* is to improve the presently imperfect understanding of crack initiation and growth. These may be affected by many different types of inhomogeneities, pores, grain boundaries and inclusions, to mention just a few factors. Grain size also has been found to affect strength, strength generally decreasing with increasing grain size. Hence a paradox: increased severity of firing treatment reduces porosity, but also increases grain size.

Indicative of the problems in improving strength of ceramics is the present lack of agreement as to how strength is affected by the flaw-severity distribution. The flaw theory of fracture can account for the scatter in strength values obtained for a given ceramic materials. But no agreement can be found on how the severity of flaws and distribution of flaws within the body affect strength.

Basically, theories fall into two general classes:

1. The "weakest-link" approach, most widely accepted, holds that fracture of the single most severe flaw results in total fracture of the specimen.
2. The other theories hold that total fracture need not result from a single flaw. Fracture of a single flaw results in a redistribution of stresses, total fracture then occurring when the remaining material can no longer carry the redistributed load.

In looking ahead it might be fair to say that substantial improvements in strength of ceramic materials will come only through better understanding of the structure of polycrystalline materials and its relation to performance. With this understanding, processing techniques will also be improved to obtain the structure necessary for maximum strength.

Systems approach shows results

Although original interest in the systems approach centered on creation of ductility, improvements in other properties have shifted the emphasis of development work. In fact, many researchers now feel that this approach is one of the most interesting for developing ceramic materials with specialized performance capabilities.

Although many different types of composites have been investigated, at present the three types of greatest interest are 1) cermets, 2) "mosaic" ceramics, and 3) fiber-reinforced ceramics.

Cermets well established

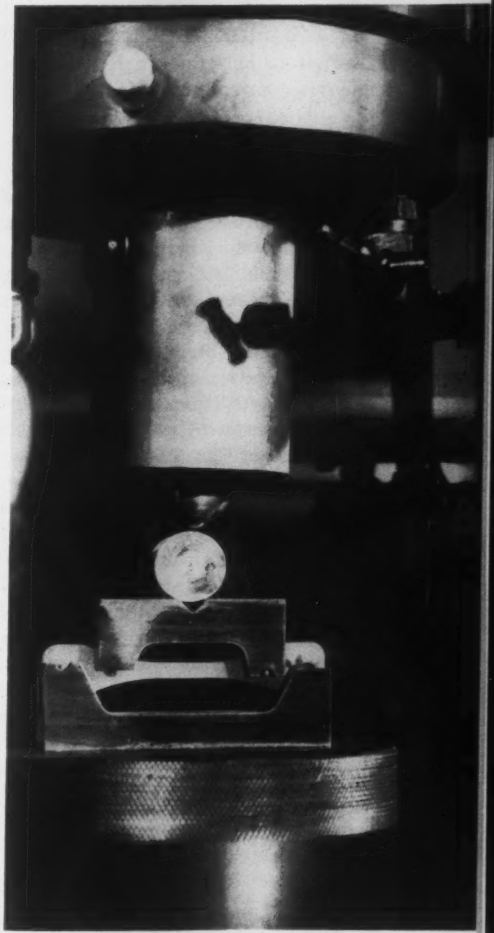
The "ups and downs" of cermets have been widely reported. Too often such materials have in effect combined some of the worst properties of each component. But dissatisfaction with cermets has been primarily on the part of those seeking the heat resistance of ceramics combined with the ductility of metals for structural applications.

On the other hand, many cermets (e.g., bonded carbides and oxides) have provided, along with some useful increases in impact resistance, improvements in strength, hardness, rigidity, and wear and abrasion resistance. Such materials have been widely employed in cutting tools, extrusion and heading dies for metals, impellers for abrasive and corrosive slurries, valve and pump seats and seals, and gas turbine buckets.

Mosaics resist shock

The mosaic approach is typified by use of a metal honeycomb structure, each cell of which is filled with ceramic. One of the earliest successful types was Avcoite, developed by Avco Corp. for missile nose cones.

Each cell of ceramic is small enough to prevent fracture due to thermal shock, and the metal cell walls provide sufficient ductility to compensate for the small amount of thermal expansion caused by heating. This system was designed for short-term, ultra high temperature use, the maximum exposure time being limited by the metal component.



Armour Research Foundation

Radical improvement *in usable strength can only come from better understanding and control of microstructure. This press is used in Armour's investigations of brittle materials fracture.*

A similar approach for longer-term service is reported by *Sterry* of Boeing. One face of a honeycomb of paper or wax is anchored in a ceramic plate, and the cells filled with ceramic. Each cell core of ceramic is long enough or thick enough so that the transition in section size from the end to the base plate is gradual enough to prevent thermal shock failure. The paper or wax is burned out

"The limit on strength of a ceramic of any given composition is imposed today by the methods and conditions of manufacture used, which fix the microstructure." —W. H. Duckworth, Chief, Ceramic Div., Battelle Memorial Institute.

either prior to or during service, leaving an all-ceramic structure.

Fibers add to strength

Fiber reinforcement of ceramics has received much attention and appears promising for improving strength, mechanical shock resistance, and thermal properties. There are two relatively distinct approaches: metal fiber reinforcement where structural and thermal requirements predominate, and quartz fiber reinforcement where electrical requirements are imposed on top of structural requirements.

Most work on metal fiber reinforcement has consisted of hot pressing metal fiber or a metal fiber mat with an oxide ceramic so that, while cooling, the metal fiber is stressed in tension, the ceramic in compression, resulting in a desirable prestressed condition. Although few performance data are available as yet, the approach appears promising.

With quartz fiber reinforcement, most work has consisted of fabrication by filament winding techniques similar to those used for reinforced plastics. One of the most interesting experimental results to date, as reported by *Plant, et al*, of General Electric, is a quartz-fiber-reinforced aluminum phosphate system. Produced by filament winding and low pressure, low temperature cure techniques, composites retain 8000-9000 psi flexural strengths after aging 6 hr at 1300 F. Such work is still developmental. Main problems: the ceramic matrix both corrosively attacks the fibers and lacks enough elongation to permit the fibers to assume maximum stress.

Ceramic fibers promising — Stimulated to a great extent by promising results in fiber-reinforced composites, much work has been devoted to development of ceramic fibers. Fibrous forms of both single crystal and polycrystalline materials have strengths more closely approaching the theoretical than any other form.

In terms of commercial ceramic fibers, the surface has not been scratched. At present, ceramic fibers of appreciable length are limited to glasses, quartz, aluminum silicate and graphite.

Investigations have been reported on fibrous single crystal sapphire (Al_2O_3) with tensile strengths of about 3,000,000 psi; work has also been reported on polycrystalline alumina, beryllia, zirconia, and silicon carbide.

According to Harman, "The next decade will bring dramatic advancements in ceramic fibers. . . . Polycrystalline fibers (actually small ribbons) prepared by evaporating salt solutions and oxide sols will grow in importance and value. . . . At present maximum tensile strengths of such micro-ribbons are in the range of 40,000 to 60,000 psi. Improvements in this respect will be made."

Such ceramic textiles would have immediate uses as high temperature filtering media, etc., but their uses as reinforcement for both metals and plastics, as well as other ceramics, holds out the promise for composite materials of radically improved, nonbrittle strength.

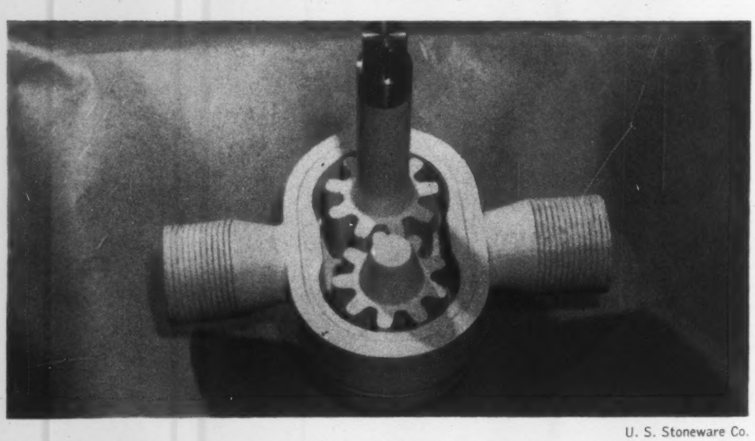
Processing: better control of structure, lower cost

Of critical interest to engineers, designers and materials specialists are developments in processing that will 1) improve control of microstructure, and 2) reduce per-part cost.

Microstructure a key to performance

As emphasized before, microstructure of a ceramic is all-important in determining its engineering properties. The limits on strength properties of ceramics today are imposed by the methods and conditions of processing the ceramic, which establish its microstructure.

In addition to strength, microstructure has a critical effect on certain electrical properties. According to *G. Economos*, of Massachusetts Institute of Technology, "The importance of microstructure (on electrical properties) of ceramics has not been stressed adequately in the past." He cites an ASTM study in which one lot of barium titanate powder was



U. S. Stoneware Co.

Critical requirements *for performance under severe environmental conditions are turning more materials men to ceramics. This acid-proof high temperature gear pump is made of a high alumina ceramic.*

distributed among five manufacturers who followed explicit instructions on body preparation but were permitted to use their own firing schedule. Variations in capacitance values were as large as 19% between producers, and as large as 7% among specimens produced by a single producer.

Increased control of equipment

In general terms, there has been substantial progress in developing better techniques and equipment for processing ceramic materials. Such techniques as isostatic (hydrostatic) pressing and hot pressing, combined with more closely controlled firing equipment, have permitted large improvements in reproducibility and quality, plus control of structure.

According to W. W. Perkins, of U. S. Stoneware, "Improved presses, extruders and mixing equipment enable more to be done in shorter time, with far greater reproducibility, than thought possible a few years ago. Also, many massive shapes are being made today which contain no clay or other natural plasticizing agents. This was unheard of not long ago."

But despite these continuing improvements, the maximum benefits of greater control over structure cannot be realized until more is known about the effect of basic structure on performance.

Two major developments

In looking ahead, there appear to be two specific techniques for controlling structure that may provide substantially improved ceramic materials. Briefly, they are:

Hot pressing and sintering—Although hot pressing is relatively well developed as a laboratory tool, it is little used in commercial production. The major benefit it appears to offer is a closer approach to theoretical density (minimum porosity) while at the same time minimizing grain growth. Such a combination should result in higher strength, with greater reproducibility of quality.

Nucleation — Nucleation and crystal growth in a glass material can produce a polycrystalline, so-called glass ceramic. According to *S. D. Stookey,* of Corning Glass

What Are Ceramics?

There are almost as many definitions of "ceramics" as there are ceramists and ceramic engineers. This is undoubtedly due to the segmented and specialized nature of the ceramic industry.

According to the American Ceramic Society, ceramic products can be defined as those manufactured "by the action of heat on raw materials, most of which are of an earthy nature (as distinct from metallic, organic, etc.), while of the constituents of these raw materials, the chemical element silicon, together with its oxide and the compounds thereof (the silicates), occupies a predominant position."

Such a definition is certainly broad, and possibly the only one suitable for an industry that includes materials ranging all the way from lime and gypsum to abrasives.

Engineering classification

For our purposes, ceramic materials can be grouped by type of performance for which they are intended. Thus, ceramic engineering materials include:

1. *Electrical and electronic ceramics*—Ceramic materials selected because of their ability to serve as a dielectric, such as steatite, alumina or forsterite; as a conductor, such as graphite or carbon; or as a solid state electronic component, such as a magnet, a thermoelectric element or a transistor.
2. *Refractory ceramics*—Ceramic materials selected primarily because of their ability to resist heat, which include both furnace refractories and the "technical" refractories used for missile throat liners and nose cones.
3. *Mechanical ceramics*—Ceramic materials selected primarily because of some mechanical characteristic, such as strength, rigidity, hardness, or abrasion and erosion resistance.
4. *Optical ceramics*—Ceramic materials selected primarily because of their light transmission or refraction characteristics. This group includes, in addition to conventional glasses, the variety of materials selected for their transmission characteristics in wavelengths other than those of visible light.
5. *Chemical resistant ceramics*—Ceramic materials selected primarily for their resistance to chemicals of various types. This type often overlaps refractory ceramics where the requirements call for resistance to molten materials of various types.
6. *Nuclear ceramics* — A relatively new group, these materials are selected primarily because of their abilities to perform a variety of functions in the nuclear field. They include materials serving as fuels, controls, and shielding.

Semantic no-man's land

A large number of materials lie in limbo, not easily grouped into the accepted classifications of engineering materials. Actually, the classification itself is relatively unimportant, as long as terms used are defined. For example, many would not classify graphite as a ceramic; some would not even classify glass as a ceramic. We include these materials here.

Probably the best example of not easily classified materials is many of the solid state electronic materials. The compound semiconductors, such as bismuth telluride, gallium arsenide and lead telluride, are prime examples. Actually intermetallic compounds, they have often fallen into the ceramic category partly because of the reluctance of many conventional metallurgists to accept them. Another contributing factor has been the fact that applications research in areas of use for such materials has previously involved ceramic materials.

> *"We believe that processing is one area where more progress will be made within the next five years than has been made in the ceramic industry for the past twenty . . ."* —L. Ferreira and V. Wolkodoff Research Dept., Coors Porcelain Co.

Works, such an approach: 1) permits use of simple glass-forming techniques, which can also permit fabrication of difficult shapes, 2) permits use of new compositions to make ceramic structures, and 3) improves properties by eliminating porosity, minimizing shrinkage and distortion of shape, and providing uniform fine-grain structures.

The end result is high strength, reproducibility, and new combinations of physical, electrical and chemical properties.

Higher volume, lower cost

Contrary to the ideas of many unfamiliar with ceramics, automated techniques are relatively widely used for forming many types of ceramic parts, electrical parts in particular. Here, dry pressing techniques minimize cost because, as Neff points out, "one of the most expensive things done in processing ceramics is to put water in and to take it out again." Dry ceramic materials, along with suitable organic binders, are molded both on automatic punch or rotary presses and by isostatic (hydrostatic) and hot pressing techniques.

Neff believes that ceramic processors might well take a good look at plastics processors in their use of injection molding techniques. And possibly one of the most promising developments in high production ceramic processing is the result of just such a look.

Injection molded ceramics

Although the use of the injection molding technique for forming ceramics is not new, according to MIT's *W. D. Kingery*, its use has been limited in the past by major problems in body formulation, the large amounts of resins required, and control of the firing process.

Recently, one company announced process developments that permit it to produce a wide range of ceramic compositions by this method economically and in large quantities—and in other than relatively simple shapes.

According to *R. L. Randolph*, of American Lava Corp., benefits of the process include the following:

1. Automatic molding in multicavity molds greatly reduces per-part cost.
2. The method of mold filling permits production of complex parts impossible to produce economically in large quantities by other methods.
3. Part-to-part reproducibility of dimensions is greater than that economically possible by machining.
4. The mixture of materials used is less sensitive to such process variables as moisture and humidity than mixes traditionally used in dry pressing and extruding; consequently closer tolerances are possible.

Although such progress in processing is noteworthy and indicative of further future improvements, this in itself is not sufficient to substantially increase ceramics' structural potential. Two basic problems remain to be solved: 1) the moot relationship between purity of raw materials and strength, and 2) the imperfect understanding of the basic mechanism of fracture.

With solutions to these two problems, the better control available in processing could be fully put to use in developing the structure known to provide the type of performance demanded.

Acknowledgments

We would particularly like to thank the following for their time and effort in personally communicating their thoughts on ceramics to us:

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Coors Porcelain Co.
Corning Glass Works
Ferro Corp.
Gladding, McBean & Co.
McDanel Refractory Porcelain Co.
National Carbon Co., Div. of Union Carbide Corp.
Saxonburg Ceramics, Inc.
U. S. Stoneware Co.

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first in silicones

Dow Corning

SILICONE NEWS

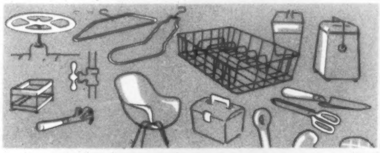
for design and development engineers • No. 86

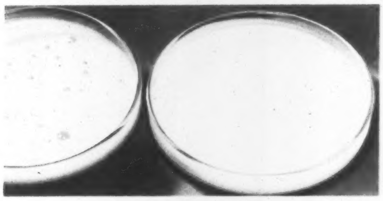
New "Product Improvers"

Since silicones can improve the quality of many components you buy, it may pay to pass on your silicone savy to your suppliers. For example, silicone additives can make a big difference in the quality of plastisol coatings and polyurethane foams — two materials of considerable promise in the product design field. Here's how —

Plastisol Coatings—Is the coating uneven or wrinkled? Does it have pinholes or cavities? Weak spots allow moisture to penetrate . . . exude rust discoloration . . . eventually chip off or flake away to expose bare metal. Why tolerate this unnecessary problem when your supplier can eliminate it by including Dow Corning Silicones in his formulation?

Silicones speed deaeration . . . prevent bubbles . . . cause plastisols to flow faster and more evenly. Silicones make possible thinner, lighter coatings free of cavities, pinholes and other weak spots. In many products such as furniture coverings and bushings, silicones give added "slip", improve mar and scuff resistance.

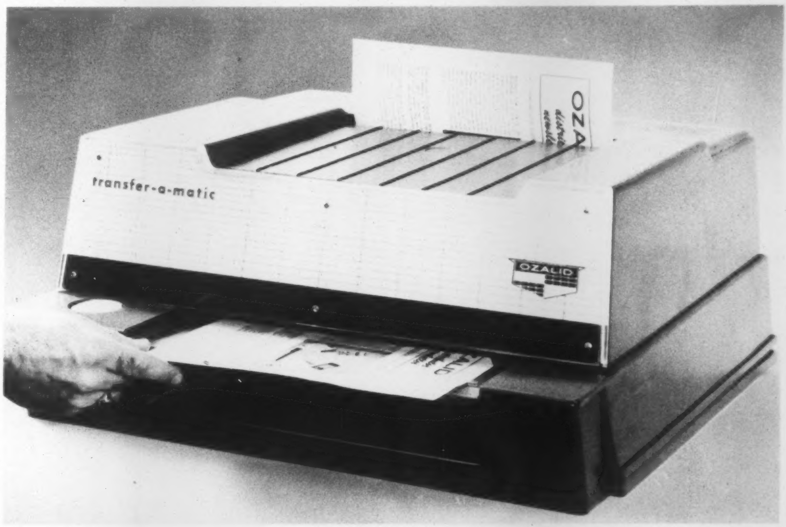




Both dishes were filled at the same time with the same plastisol solution, but a silicone additive was added to the solution before it was poured into dish at right. Note the absence of bubbles (entrapped air) in this dish.

Polyurethane Foams—Whether you use rigid or flexible foam — silicone additives can prove invaluable in helping your fabricator supply you with a high quality, low density foam that has uniform cell structure, time after time . . . that is free of partial fills, blowholes and other defects.

Your supplier will find Dow Corning silicone additives are economical, too, because lower concentrations — up *(Cont. Pg. 2)*



HASN'T STUCK YET!

Q: "How to get stick-proof rubber rollers?"

A: "Make them of Silastic, the Dow Corning silicone rubber", according to design and development engineers in the Ozalid Division of General Aniline and Film Corporation.

Ozalid produces the famous Transfer-a-matic copying machine for office and engineering use. During field tests of early prototype models, the sensitized side of copy paper sometimes stuck to the rubber rollers that squeeze off excess developer solution as the paper emerges from the bath. The result was torn paper or a jammed machine. The problem was especially acute after the rollers had dried during periods of idleness.

Here's how the Special Products Engineering Group at Ozalid described their solution: "On the recommendation of a Dow Corning sales engineer, we had some test rollers made of Silastic. After installing them on prototype models, we put the machines (and rollers) thru operational tests that were much more severe than actual service would be. The squeegee rollers made of Silastic came through with flying colors.

"The sensitized paper stripped off these rollers without the slightest hesitancy — under all conditions tested. What's more, neither the silicone rubber nor the developer solution reacted on each other. And no discoloration of paper has been noted. As a result, Silastic rollers are now standard equipment on all production model Transfer-a-matic machines."

Performance like this is typical of Silastic® the silicone rubber that remains resilient and tack-free despite exposure to many fluids, chemicals, steam, heat, cold, and weathering. For more information about Silastic and a list of rubber companies manufacturing parts made from this silicone rubber, circle . . . . . *No. 241*

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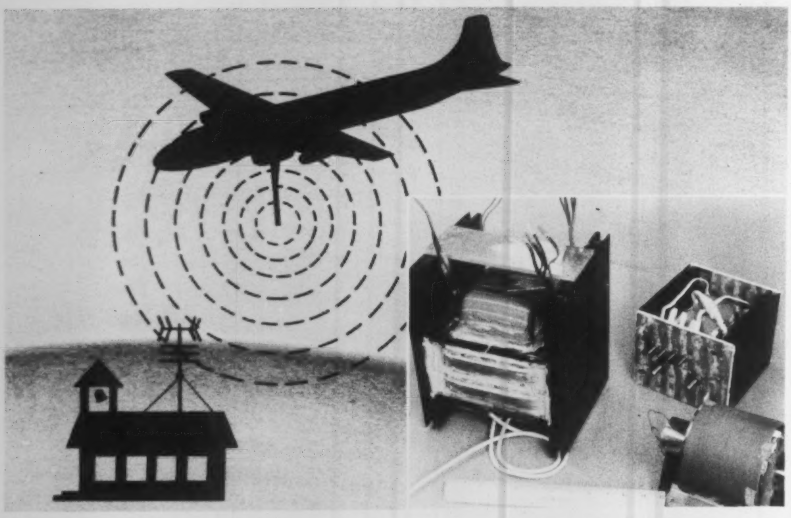

EDUCATIONAL "PROBE"

Taped TV lectures will become standard classroom fare in hundreds of schools in six Midwest states as Fall semesters get underway. Their point of origin: two airborne DC-6's converted by Westinghouse engineers into powerful, aerial, transmitting centers.

From 23,000 feet, the DC-6's will send TV signals having an effective range of 150 to 300 miles — many times the 60 to 70 mile range of ground based transmitters. Another advantage, each aircraft is capable of transmitting more than one lecture simultaneously on each of two channels.

With educators looking hopefully over their shoulders, Westinghouse engineers have taken every precaution to assure the most reliable functioning of the complex telecast equipment. In this department, they've had a big assist from Dow Corning silicone insulation as a means of saving weight, reducing bulk and building a high reliability factor into power supplies.

Among the items of equipment insulated with Dow Corning Silicones are:

1. Rectifier Transformer. Three single phase transformers have been combined to produce a three-phase rectifier transformer rated at 35 KVA, 400 cycle, to supply the 16 KV high voltage output. Total weight of 3 transformers and mounts: 165 pounds.
2. Buck Boost Transformer. Three of these units are wired together to produce a three-phase transformer rated at 9 KVA. Total weight: 50 pounds.
3. Filter Choke. Two units with a rating of ½ henry at 3 amperes are used in the power supply. Total weight: 50 pounds.

All units are forced-air cooled and the weights given above include the weights of the cooling ducts.

Mr. Ray Lee, components design engineer for Westinghouse Air Arm, estimates the silicone insulated transformers weigh only half as much as they would if they were Class A insulated. They help appreciably in keeping down the total weight of the transmitting equipment . . . provide the ultimate in dependable operation. For more information explaining why it will pay you to investigate Dow Corning silicone insulation, circle . . . . *No. 242*

Announcing New Customer Service

A new customer service facility has been established by Dow Corning to render complete and comprehensive engineering service to end users and fabricators of parts made from SILICONE MOLDING COMPOUNDS.

Dow Corning developed the first silicone molding compounds about 1948. Since then, our R&D people have produced several excellent materials, noted for their resistance to high and ultra-high temperatures. Thanks also to outstanding physical and electrical properties, these compounds have gained specification in a wide variety of commercial and military applications.

In recent years the performance demands placed on silicone molding compounds have become increasingly severe. To meet these more exacting requirements, we've turned more and more to custom compounding.

This, plus the obligation we have to fabricators to help them mold these custom compounds, led us to the establishment of the new ASG (Application Service Group) Molding Compound facility. For full information on Silicone Molding Compounds and the unique engineering service available from Dow Corning, circle . . .*No. 243*

ASG
MOLDING
COMPOUNDS
ASG MOLDING COMPOUNDS
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SILICONE ADDITIVES *(Cont.)*

to 25% less — produce consistently high quality foams with uniform cell structures.

Why not suggest these silicone "product improvers" to your suppliers? You'll get better components . . . produce better products. For more detailed information about silicone additives for plastisols, circle . . *No. 244*. For details about polyurethane additives, circle . . . . . . *No. 245*

Dow Corning Corporation, Dept. 7421, Midland, Michigan

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Physical Properties of the Metals

Metal ↓	Density, lb/cu ft	Melting Pt, F	Boiling Pt, F	Latent Heat of Fusion, Btu/lb	Latent Heat of Vaporization, Btu/lb	Elec Res, microhm-cm[e]	Ther Cond, Btu/sec/sqft/°F/in.
Aluminum	168.6	1220	3735	171.5	4070	2.83	0.42
Antimony	417	1167	2624	69	690	41.7	0.0363
Arsenic	357.7	1503	1130[a]	159	—	33.3	—
Barium	218.5	1310	2732	—	1130	—	—
Beryllium	114.9	2343	5378	466	10650	5.88	0.31
Bismuth	611.8	520	2691	23.4	368	106.86[f]	0.0161
Boron	146.1	3812	4622	—	—	775×10^9	—
Cadmium	540	609	1413	23.8	516	6.83	0.085
Calcium	96.8	1562	2624	100	2038	4.24	—
Cerium	423.3	1460	4383[b]	27.2	—	60-89	—
Chromium	445.7	2822	4500	145.5	2658	13	0.133
Cobalt	556.9	2719	6422	111.5	2700	5.68	0.11-0.137
Columbium	535	4380	5972	—	—	13.2	—
Copper	559.4	1981	4703	88	2060	1.72	0.76
Gallium	372.7	85.5	3600	34.4	1825	56.8	0.0565-0.0725
Germanium	332.1	1756	4892	203	2970	60×10^6	—
Gold	1204.9	1945	5570	27	747	2.44	0.57
Hafnium	817.2	3865	9752	—	—	32.4	—
Indium	456.4	313	3632	12.2	870	9	0.046
Iridium	1399.7	4450	9572	47	—	4.9	0.113
Iron	491.3	2804	4955	122.3	2730	10	0.153
Lanthanum	386.4	1535	7667[c]	—	—	—	—
Lead	708	621	3123	10	366	22	0.067
Lithium	33.1	367	2437	59	9200	11.7	0.137
Magnesium	108.6	1204	2017	160	2408	4.6	0.298
Manganese	464.5	2273	3800	114.8	17600	185	—
Mercury	845.9	—38	675	5	125.3	95.8	0.0161
Molybdenum	636.8	4716	8672	126	2410	5.78	0.308
Nickel	555.6	2651	4950	128.8	2680	7.8	0.173
Osmium	1403.4	4892	9932	—	—	9.5	—
Palladium	750.4	2829	7196	69.5	—	10.8	0.137
Platinum	1339.1	3223	8154	43.2	985	10.6	0.137
Praseodymium	424.5	1742	5954[d]	34.6	—	88	—
Rhenium	1323.5	5733	10652	76.3	1470	21	—
Rhodium	776.6	3571	8132	—	—	4.5	0.169
Ruthenium	761.6	4352	8852	—	—	7.16-7.6[f]	—
Samarium	432.6	2462	—	—	—	—	—
Selenium	300.3	422.6	1270	29.6	290.6	12	0.000565-0.00143
Silicon	144.8	2570	4496	710	4550	15×10^6[g]	0.161
Silver	654.9	1760.9	4014	47.7	1130	1.59	0.786
Sodium	60.6	208	1621	49	1810	4.5	0.26
Strontium	162.3	1418	2516	45	1880	23	—
Tantalum	1036.3	5425	9572	—	—	12.4	0.105
Tellurium	389.6	846	2534	13.3	286	200,000	0.0113
Thallium	739.8	577	2655	9.1	342	18[f]	0.075
Thorium	730.4	3348	8132	35.6	1008	18.6	—
Tin	455.7	449	4118	25.1	1030	11.5	0.124
Titanium	280.9	3074	6395	187	—	47.8	0.33
Tungsten	1204.9	6080	10652	79.1	1710	5.48[f]	0.25
Uranium	1189.3	2071	7100	19.8	438	29[f]	0.0565
Vanadium	381.4	3452	5432	—	—	24.8[f]	0.0597
Yttrium	270.9	2646	—	—	—	—	—
Zinc	445.8	787	1663	43.9	755	5.8	0.212
Zirconium	405.8	3326	9032	—	—	45	0.0323

[a] Sublimes. [b] ±126. [c] ±270. [d] ±160. [e] 68 F. [f] 32 F. [g] 572 F.

Source: *Rare Metals Handbook*, Reinhold Publishing Corp., 1954.

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For more information, turn to Reader Service card, circle No. 322

Galvanized sheets up to 72 in. wide are now being produced by Armco Steel Corp. on what is claimed to be the "widest continuous sheet galvanizing unit ever built." The new $8 million galvanizing line has an average capacity of 30 tons of zinc-coated sheet or coil per hr.

Production of polyethylene film is being doubled at Du Pont's plant in Richmond, Va. When the expanded facilities are in full operation about the middle of 1962 the plant will have a capacity of more than 60 million pounds per year.

Steel production for the first half of this year amounted to 44,860,000 net tons, compared to 60,750,000 tons for the first half of 1960, according to the American Iron and Steel Inst. Shipments of finished steel products for the first six months of 1961 totaled 31,230,000 tons, 27% less than the 42,850,000 tons shipped during the same period of 1960.

More polypropylene will be available when Dow Chemical Co., AviSun Corp. and Enjay Chemical Co., Div. of Humble Oil & Refining Co., open new and expanded facilities this fall. AviSun's new plant at New Castle, Del. has a rated capacity of 100 million pounds per year. Enjay says its polyolefin plant at Baytown, Tex. is being expanded by approximately 50% from an initial rated capacity of 40 million pounds per year. Dow has not given production figures but says it expects its Torrance, Calif. plant to be in full-scale production this month.

Powder metal parts up to 5 ft long and 12 in. in dia are being marketed by the Carmet Div. of Allegheny Ludlum Steel Corp. The parts are made on a new hydrostatic press that exerts 50,000 psi.

A new steel sheet for one-coat porcelain enameling has been put into commercial production at the Lackawanna, N. Y. plant of Bethlehem Steel Co. The steel sheet is called Bethnamel.

A price cut on man-made natural rubber (polyisoprene) has been put into effect by Shell Chemical Co. New price is 26¢ per lb in truckload lots, down 2¢ per lb. Shell has a 40 million-pound-per-year polyisoprene plant in operation at Torrance, Calif. and is building a new plant at Marietta, Ohio with a capacity of 80 million pounds per year.

Commercial production of mill products of columbium, vanadium and a new columbium alloy (see p 162 this issue) has been announced by Haynes Stellite Co., Div. of Union Carbide Corp. The metals are produced as rod, bar, wire, strip, sheet and plate.

What's News In Plastics...

Escon® polypropylene offers molders a balanced combination of properties for a wide range of molding applications such as high strength and impact resistance in automobile dash boards ...excellent electrical properties for cable connectors ...high heat distortion temperature in vaporizers ...low water pick-up in distributor caps ... outstanding dynamic fatigue resistance for "living hinge" in accelerator pedals and snap-fit closures → for containers...outstanding chemical resistance plus high gloss, surface hardness, and quality "feel" in dinnerware. All available for volume production at low cost.

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Prices of Materials

*Changes since last semi-annual report in March are bold-faced; *indicates a price decrease*

NONMETALLICS

Prices for large quantities for range of grades, color, sizes; given in $/lb

RUBBER

Material	Dry	Latex
Butadiene-Acrylonitrile	**.46***-.68	.45-.54
Butadiene-Styrene	**.14-.35**	.26-.32
Butyl	.23 **.30**	.35
Kel F	**16.0**	—
Natural[a]	.30	.37
Neoprene[b]	.39-.75	.37-.50
Polysulfide[b]	.50-1.25	.80-1.25
Silicone[b]	**2.50**-4.00	—
Urethane	1.15-1.65	—
Viton	10.0-13.0	—

[a] Spot price end of August.

[b] Less than carload quantities for dry rubber.

REINFORCED PLASTICS LAMINATE SHEET

Type	0.025-¼ In.	⅜-2 In.
Paper-Base Phenolic (X, P, PC, XX, XXP, XXX, XXP)	.90-1.20	.82-1.22
Cotton Fabric-Base Phenolic (C, CE, L, LE)	1.20-1.90	1.36-1.76
Asbestos-Base Phenolic (A, AA)	1.20	.96-2.70
Glass-Base Phenolic (G-3)	3.25	2.60
Glass-Base Melamine (G-5)	2.50	2.30
Glass-Base Silicone(G-7)	6.50	5.90
Nylon-Base Phenolic (N-1)	3.90	3.54

THERMOSETTING PLASTICS

Material	Molding Compounds	Laminating, Casting Resins
Alkyd	.43-.60	—
Epoxy	—	.45-.80
Melamine	.42-.45	.40-.41
Phenolic	.20-.35	.17-.34
Polyester	.26-.39	.33-.53
Silicone	**2.40*-3.55***	1.55-1.74[a]
Urea	.19-.34	—

[a] 60% solids content.

All prices are approximate and given solely for general guidance of those responsible for materials selection.

THERMOPLASTICS

Material	Molding Compound		Sheet (.030-.250)	Rod (⅛-¼)	Tube (⅛-¼)
	Base	Per Cu In. As Molded, ¢[a]			
Acetal	.65	3.3	—	—	—
Acrylic	.46-.55	1.8-2.3	.49-2.15	.90-1.15	1-1.15
Chlorinated Polyether	2.50	12.6	—	—	—
Cellulosic					
Acetate	.36-.58	2.1-2.8	.92-1.16	.75-1	.85-1
Butyrate	.40-.62	2.0-3.0	1-1.28	.95-1.20	1.05-1.20
Nitrate	—	—	1.60-2.73	1.45-1.75	2.25-5.00
Propionate	.62	2.7	—	—	—
Fluorocarbon					
CFE	7-8	53.0-61.0	15-23	18-22	20-22.50
TFE	3.25-5.00	25.0-38.5	11-14	13	13
Nylon	.98-2.18	4.0-9.0	—	3	3
Polycarbonate	1.30-1.75	5.6-7.5	—	—	—
Polyethylene	**.26*-.35***	0.86-1.2	.85-1	.75-1	.85-1
Polypropylene	.42-.58	1.3-1.9	—	—	—
Polystyrene	.19-.43	0.72-1.7	.57-.61	.65-.90	.75-.90
Vinyl	.24-.43	0.10-2.4	.62-.92	.75-1	.85-1

[a] Cost of base molding compound in ¢/lb divided by molded specific volume in cu in./lb.

NONFERROUS METALS

Mill base prices for large quantities; given in $/lb except where indicated

ALUMINUM

Material	Ingot	Sheet[a]	Plate[b]
Primary(99-99.9%)	.26	—	—
13, 43, 214	.26-**.29***	—	—
1100-F, 3003-F	—	.47-.57	.44
5052-F	—	.53	.47
6061-T6	—	.50	.47

[a] Thickness range 0.048-0.061 in., mill finish.

[b] Thickness range 0.250-3.0 in., mill finish.

BRASS

Form	Cart., 70%	Low, 80%	Red, 85%
Sheet, Strip	.49	**.52**	**.53**
Seamless Tubing	.56	.56	.57
Rod (not f.c.)	.49	**.52**	**.53**
Wire	.49	.52	.53

NICKEL

Form	"F"	"A"	Monel
Ingot	**.81**	—	—
Rod	—	**1.16**	**.95**
Sheet, C.R.	—	**1.47**	**1.26**
Strip, C.R.	—	**1.33**	**1.14**
Seamless Tube	—	1.57	1.29

LEAD

Common Grade	.11
Sheets[a]	16.50

[a] Rolls of 140 sq ft or more.

MAGNESIUM

Material	Ingot	Sheet[a]	Plate[b]
Primary (99.8%)	.36-.37	—	—
AZ91B (die casting)	.37	—	—
AZ91C (sand casting)	.41	—	—
AZ31B (std grade)	—	.69-1.03	.68
AZ31B (spc grade)	—	.97-1.71	.93

[a] Thickness range 0.032-0.188 in.

[b] Thickness range 0.250-2.0 in.

COPPER

Ingot (elec)	**.31**
Sheet, Strip (hot rolled)	**.56**
Seamless Tubing	**.57**
Rod, Drawn	**.53**
Wire	
Round	**.36**
Square, Rectangular	**.49**
Magnet	**.46**

(more prices on p 148)

THESE MASSIVE NEW NYLON SHAPES CAN SAVE YOU MONEY!

Nylon has been proven in service as an outstanding bearing material because of built-in lubrication, ability to withstand abrasive and corrosive environments, and mechanical strength. And MC* nylon, newest of the nylon family, is more adaptable than any and most economical of all. Tubular bars, for example, cost less than other nylon formulations . . . even less than continuous cast bronze. Plate and rod sell at prices under competitive nylons.

POLYPENCO MC nylon has premium properties similar to nylon 101 with outstanding wear life, strength and resistance to deformation under load. Typical applications: rollers, bearings, bushings, gears, cams, forming devices, wear plates, tooling and general structural wear parts.

AVAILABILITIES

TUBULAR BAR: 2"-15" O.D.
SOLID ROD: 3"-24" O.D.
LARGE PLATE: ¼"-6" Thick

SPECIAL SIZES AND SHAPES ON REQUEST

*Trademark of The Polymer Corporation

IN BUSHINGS

Non-scarring work holder bushings for disc grinding roller bearings.

IN BACK-UP ROLLS

5" I.D. x 7" O.D. x 13" long back-up rolls for die cutting outline and patterns of paper place mats and lace doilies save $2000 per machine in cost of rolls alone replacing Kraft paper rolls.

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Support rollers for end grinding roller bearings.

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For more information, turn to Reader Service card, circle No. 418

PRICES & SUPPLY

TITANIUM

Sponge (99.3+%)	1.50-1.60
Bars, Rod	3.80-6.25
Plate	5.25-9.00
Sheet, Strip	6.75-15.50
Wire	5.55-9.50

ZINC

Prime Western	11.5
Die Casting Alloys[a]	.14*
Sheet	.28
Ribbon	.23
Plates	.22

[a] Alloys 2, 3, 5.

NONFERROUS POWDERS

Aluminum[a,b]	.42
Brass[a]	.33-.50
Cobalt	1.50
Copper (elec or red.)[a]	.44
Molybdenum (98%)	3.15-4.10
Nickel	.81
Tantalum	30
Tungsten (C-red. 98.8%; H_2—red. 99+%)	3-4[c]
Zirconium	
Flash Grade	4
Electronics Grade	15

[a] Price for —100 mesh. [c] Delivered price.
[b] Freight allowed.

OTHER NONFERROUS METALS

Cadmium (bars)	1.60
Columbium	36-55
Gold	$35/troy oz
Indium (99.97+%)	$2.25/troy oz
Manganese (99.9%)[a]	.34-.36
Palladium	$24-26/troy oz
Platinum	$82-85/troy oz
Silver	90-91¢/troy oz
Tantalum (sheet, rod)	55-60
Tin (straits)[b]	1.16
Vanadium (90%)	3.45*
Zirconium (sheet, strip, bar)	11-30

[a] Delivered price. [b] Spot.

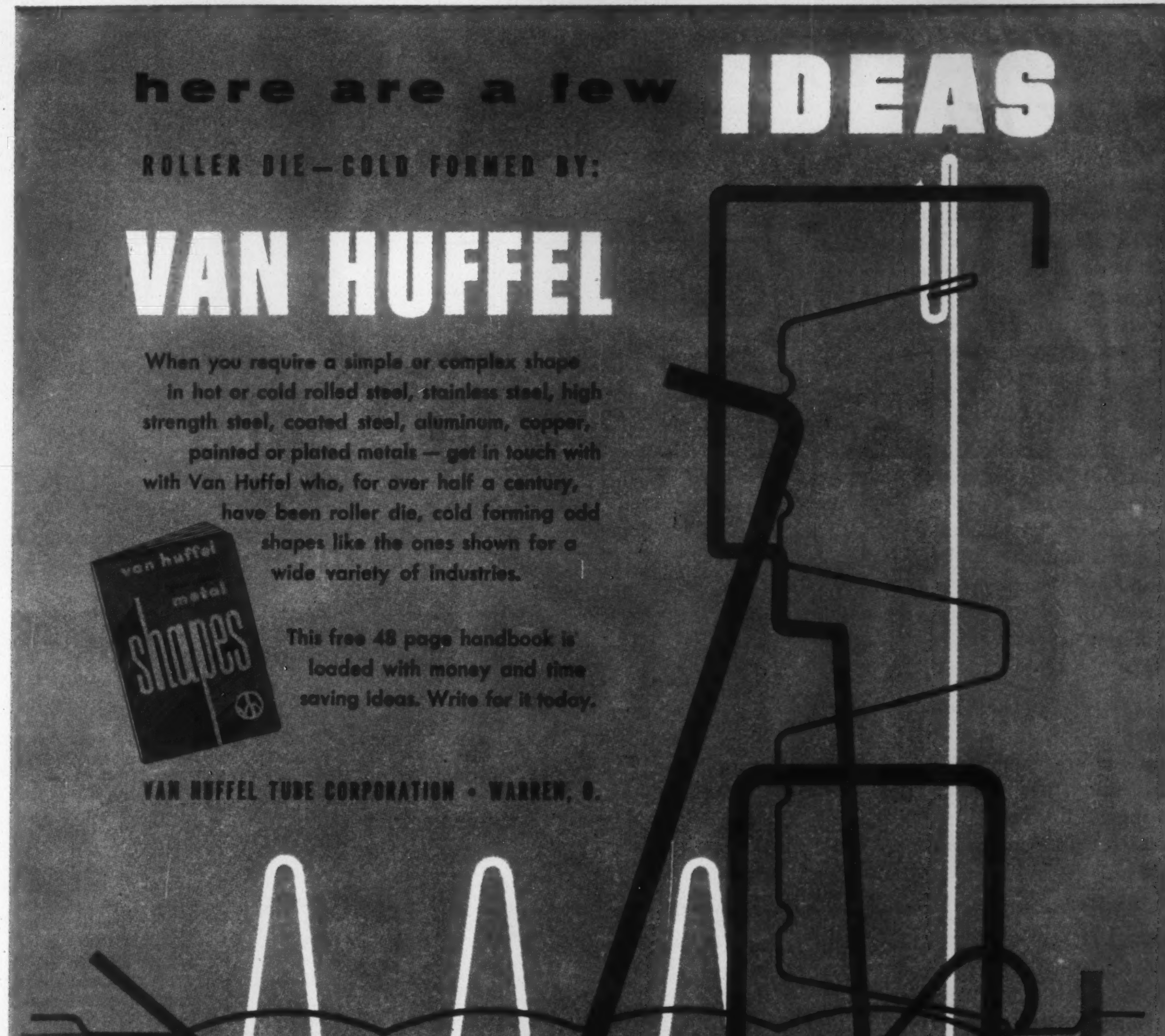
IRONS AND STEELS

Mill base prices for large quantities

SEMIFINISHED STEEL ($/net ton)

Ingots, Alloy	82
Billets, Blooms, Slabs	
Carbon, Re-Rolling	80
Carbon, Forging	99.50
Alloy, Forging	119
Seamless Tube Rounds	122.50
Wire Rods	$6.40/cwt

(more prices on p 150)



here are a few IDEAS

ROLLER DIE—COLD FORMED BY:

VAN HUFFEL

When you require a simple or complex shape in hot or cold rolled steel, stainless steel, high strength steel, coated steel, aluminum, copper, painted or plated metals — get in touch with with Van Huffel who, for over half a century, have been roller die, cold forming odd shapes like the ones shown for a wide variety of industries.

This free 48 page handbook is loaded with money and time saving ideas. Write for it today.

VAN HUFFEL TUBE CORPORATION • WARREN, O.

WHERE IDEAS TAKE SHAPE IN METAL

For more information, turn to Reader Service card, circle No. 489

LET MUELLER MAKE IT!

Mueller Brass Co. of Port Huron is much more diversified than the name "Brass" implies . . . a lot more. In fact, because of its many and varied facilities . . . its *men, methods* and *metals* . . . Mueller is in the unique position of being able to offer true single source service.

MUELLER HAS THE MEN . . . experienced engineers with the ability to work out, creatively, tough design problems, and improve a part or components for production by the most economical method. You get sound engineering plus 44 years of practical metalworking production experience when you "Let Mueller Make It."

MUELLER HAS THE METHODS . . . when you "Let Mueller Make It", you are utilizing one single source that is able to produce parts any one of these ways: as forgings, impact extrusions, sintered metal parts, screw machine products, formed tube or as castings.

MUELLER HAS THE METALS . . . and the materials . . . to produce precision parts in aluminum, brass, bronze, copper, iron, and steel in hundreds of different alloys to meet each exact requirement.

In addition, Mueller Brass Co. has complete and modern facilities for performing all types of finishing and sub-assembly operations. Another plus value is nation-wide sales engineering service.

So, in the final analysis, no matter where you fit in the American industrial picture, whether you're making missiles or mowers . . . and no matter where you're located, it will pay you to LET MUELLER MAKE IT!

MUELLER BRASS CO.
PORT HURON 21, MICHIGAN

For more information, circle No. 434

PRICES & SUPPLY

FINISHED STEEL (¢/lb)

Form	Carbon	High Str Low Alloy	Alloy
Plate	5.30	7.95	7.50
Sheet, HR	5.10	7.52	—
Sheet, CR	6.27	9.27	—
Strip, HR	5.10	7.57	8.40
Strip, CR	7.42	10.80	15.40
Bar, HR	5.67	8.30	6.72
Bar, CF	7.65	—	9.02

STAINLESS STEELS ($/lb)

Material	Forging Billets	H.R. Bars	Plate	Sheet, Strip
Austenitic				
301, 302, 302B, 303, 304, 305	.39-.44*	.46-.50	.41-.46	.51-.59
321[a]	.49	.58	.55	.66
347[a]	.58	.67	.65	.79
Martensitic				
410[a]	.29	.35	.30	.40
416	.30	.36	.31	.48
403	.29	.35	.30	.40
420, 440	.36	.43	.40	.62
Ferritic				
405, 430, 430F[a]	.31	.36-.37	.31-.33	.41-.52
442	.33	.40	.37	.56
431	.39	.46	.41	.56
446	.41	.48	.43	.70
High Mn				
202[a]	.38	.45	.40	.49
Extra Low C				
304L	.47	.55	.54	.60*
316L	.72	.84	.80	.89
Precip Hard.				
17-7PH	.69	.76	.85	.90
PH 15-7 Mo	.89	.97	1.11	1.16

[a] Ingot price approx 60% of billet price.

FERROUS POWDERS ($/lb)[a]

Sponge Iron	.11
Electrolytic Iron	
Annealed (99.5%)	.37
Unannealed (99+%)	.33
Stainless Steel	
304	.89
316	1.07

[a] Price for —100 mesh.

IRON ($/gross ton)

Pig	66-67

(more prices on p 152)

PUMP CUPS
LIP SEALS
PISTON RINGS
BEARINGS

Replace costly machined or molded parts with formed RULON® Tape.

Leading manufacturers across the country are cutting design costs by stamping or post-forming parts from RULON (filled TFE) tape. With Dixon's RULON Tape in thicknesses from .004" to .125", you pay only for what you *use*. You use a *minimum* of material . . . and reduce costs up to 10 to 1. You take advantage of RULON'S plastic memory, too, for tighter fits and better seals. RULON Tape gives your product these performance-improving qualities: (1) low friction, (2) high wear resistance, (3) low deformation under load, (4) wide temp. tolerance (−400°F to +500°F), (5) chemical inertness, (6) lube-free operation, and (7) zero water absorption.

Dixon offers RULON and TEFLON in
- rods
- tubing
- sleeving
- sheet
- tape
- extruded shapes
- bearings
- bushings
- washers
- gaskets and packings
- bearing retainers
- machined and molded parts

Whether you need stamped or post-formed parts for pumps, valves, compressors, bearings, meters, or what have you, it pays to rely on (1) Dixon's wide selection of basic shapes (in both RULON and Teflon), (2) Dixon's knowledge of fluorocarbon reinforcing agents, and (3) Dixon's facilities for fabricating parts to print.

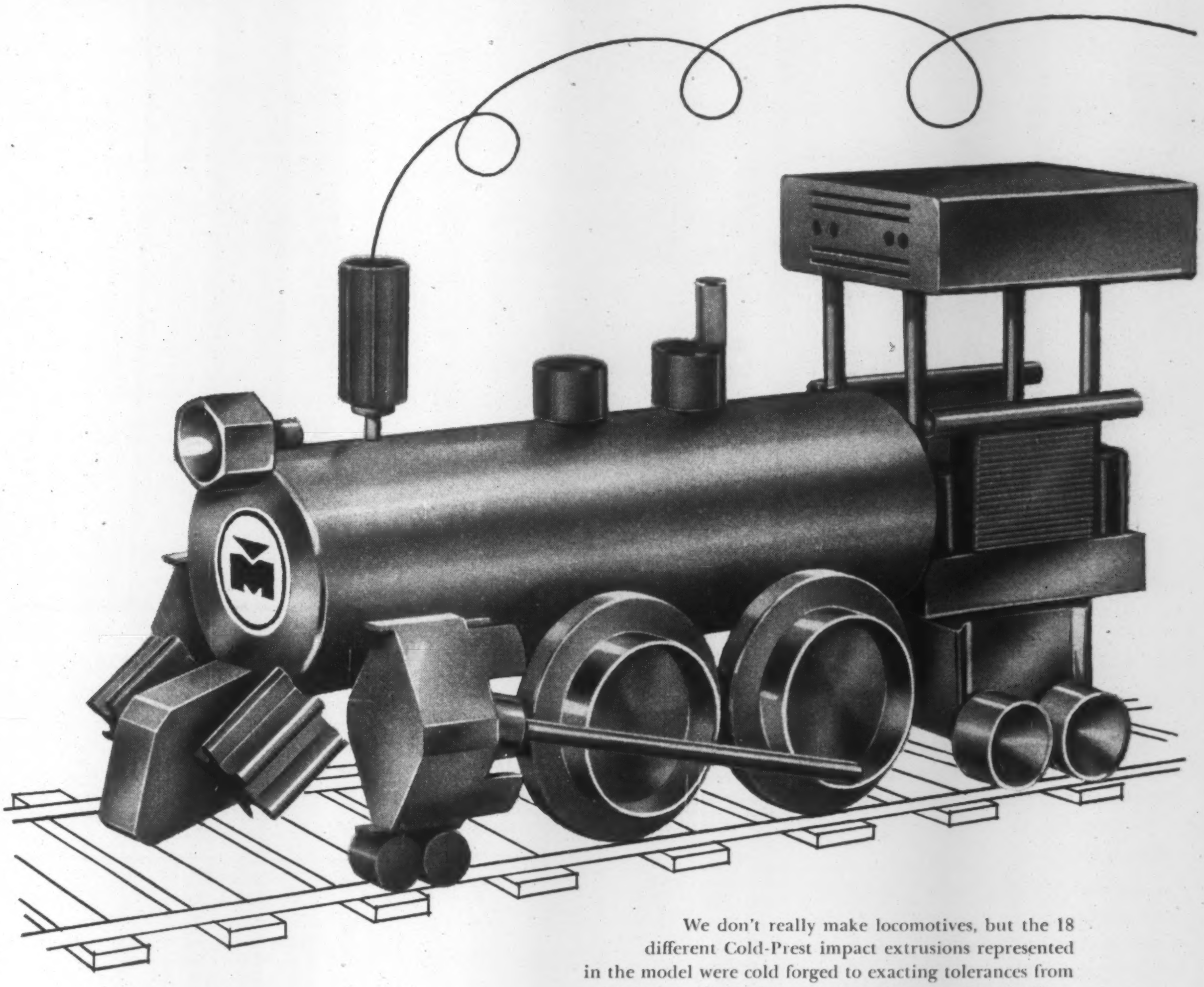
See RULON designers guide book — Bulletin #9572 in Sweet's Product Design File, or send details for recommendations. DIXON CORPORATION 102 BURNSIDE ST., BRISTOL, RHODE ISLAND.

* DuPont T.M.

DIXON

For more information, circle No. 342

MUELLER CAN MAKE MOST ANYTHING IN IMPACT EXTRUSIONS...



We don't really make locomotives, but the 18 different Cold-Prest impact extrusions represented in the model were cold forged to exacting tolerances from a number of aluminum, copper, brass, and steel alloys.

These parts are employed in products ranging from door closers to missiles. Mueller has also made important advances in the production of copper impact extrusions that are especially adaptable to electronic applications. Cold forgings are precision produced to exacting tolerances and offer the additional advantage of a better finish and appreciable metal savings.

Mueller's flexible facilities for the production of Cold-Prest Impact extrusions make practical long or short runs of simple or relatively complex shapes on an economical basis. In addition, the entire Mueller engineering staff, excellent machining, finishing and assembly facilities are readily available to you when you . . .

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PORT HURON 21, MICHIGAN

Write today for Engineering Manual No. FM-3019

344

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more engineers
are discovering BRAND NEW
USES for low cost
CLEVELITE*
laminated phenolic tubing

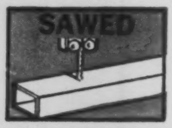
Light as aluminum, structurally strong, exceptional chemical properties and high insulation resistance—this tubing is superior to many other materials.

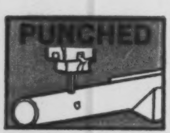
In numerous applications, imaginative engineers are improving their products with Clevelite . . . and at lower cost.

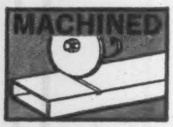
PHYSICAL PROPERTIES

Inside diameter	.090″ to 8.000″
Wall thickness	.0075″ to .250″
Length	⅛″ to 8½ feet
Heat resistance	250°F. continuous
Specific gravity	0.98—1.10
Acetone extraction	<4%
Colors	Natural & Black

CLEVELITE CAN BE...







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CLAD STEELS (¢/lb)[a]

Cladding Metal	10%	15%	20%
Stainless			
304	29	32	34
304L	34	37	40
316L	47	51	56
321	35	38	41
347	41	45	49
430	23	26	28
Inconel	**61**	**73**	**84**
Nickel	**55**	**67**	**79**
Monel	**55**	**66**	**78**

[a] Prices given for three cladding thicknesses.

TIN PLATE ($/base box)

Hot Dip (1.25-1.50 lb)	10.40-10.65
Electrolytic (0.25-0.75 lb)	9.10-9.75
Thin	6.10-6.55
Black Plate	8.20

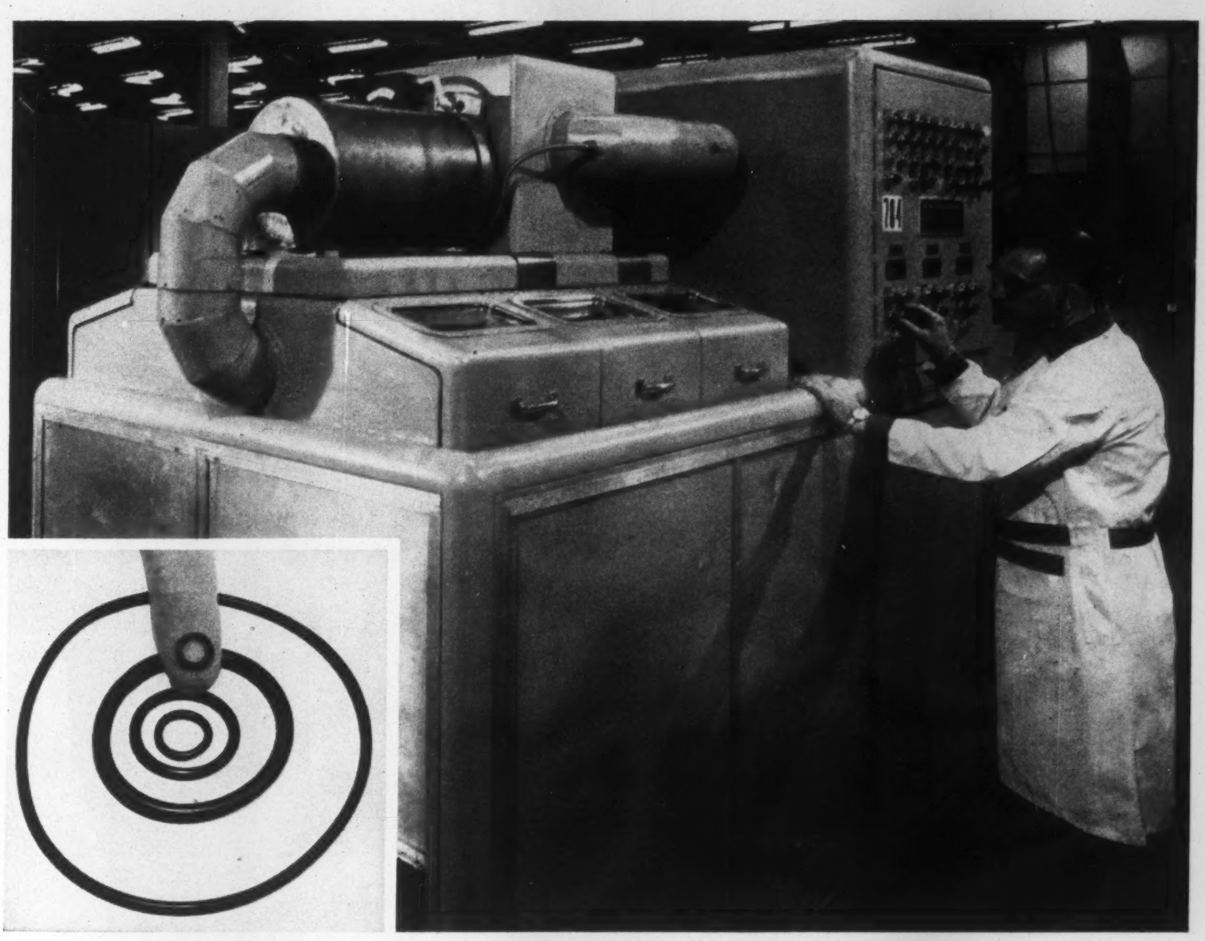
FINISHES AND COATINGS

ORGANIC COATINGS

Material	Avg Thk per Coat, mil	Mils Required[a]	Cost, ¢/sq ft/dry mil[b]
VARNISHES, ENAMELS			
Short Oil Phenolic			
Varnish	1.0	1.0	1.5
Enamel	1.2	1.0	1.75
100% Phenolic	1.0	1.5	1.75
Straight Oil-Modified			
Alkyd	1.5	1.5	1.5
Alkyd-Amine (90-10)	1.5	1.5	1.75
Alkyd-Phenolic (50-50)	1.5	1.5	1.75
Alkyd-Vinyl (50-50)	1.0	2.0	2.0
Alkyd-Styrene (70-30)	1.2	1.5	1.75
Epoxy	1.8	1.8	2.0
Silicone	.5-1.0	.5-1.0	6.0
Furane	2.0	2.0	1.0
Neoprene	5.0	5.0	1.5
DISPERSION COATINGS			
Phenolic	1.0	1.5	1.75
Vinyl	1.0	2.0	2.5
Fluorocarbon	1.0	1.0	15.0
LACQUERS			
Nitrocellulose	1.0	2.0	2.5
Vinyl	1.0	2.0	2.5
Acrylic	1.0	2.0	2.75
Butyrate	1.0	2.0	2.75

[a] Thickness over phosphate coating required for exterior durability on steel. For purely decorative coating. 1 mil will usually suffice.

[b] Materials cost only. Realistic price comparison can be made only on basis of dry applied coating, not on basis of cost per gallon.



This hydraulic "torture tester" used to blow its seals every few days, interrupting tests, delaying results, causing expensive maintenance. When auto producer switched to VITON seals (inset), trouble stopped.

SEALS SNAPPED LIKE PRETZELS...

until VITON® O-rings were installed in this hydraulic hose tester

In the lab of a major auto producer, this pressure-impulse machine pounds power-steering hose with 1500 psi surges of hydraulic fluid at 325°F. at the rate of 600 cycles a minute—hour after hour.

Formerly, many kinds of good oil-resistant seals baked out, leaked badly—sometimes within a few days; actually were too brittle to be removed intact. But now, VITON O-rings go for months without losing their resiliency or stability. They are replaced only on routine overhauls.

Frequently, as in this case, VITON is the only synthetic rubber that can perform dependably in environments combining high heat with fuels, lubricants or hydraulic fluids. That's why VITON is solving more and more design problems in critical seals, gaskets, diaphragms, hose tubes, valve parts and couplings. Contact your rubber supplier for more information, or write: E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Department MDE-9, Wilmington 98, Delaware.

DU PONT
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VITON®
SYNTHETIC RUBBER

Better Things for Better Living . . . *through Chemistry*

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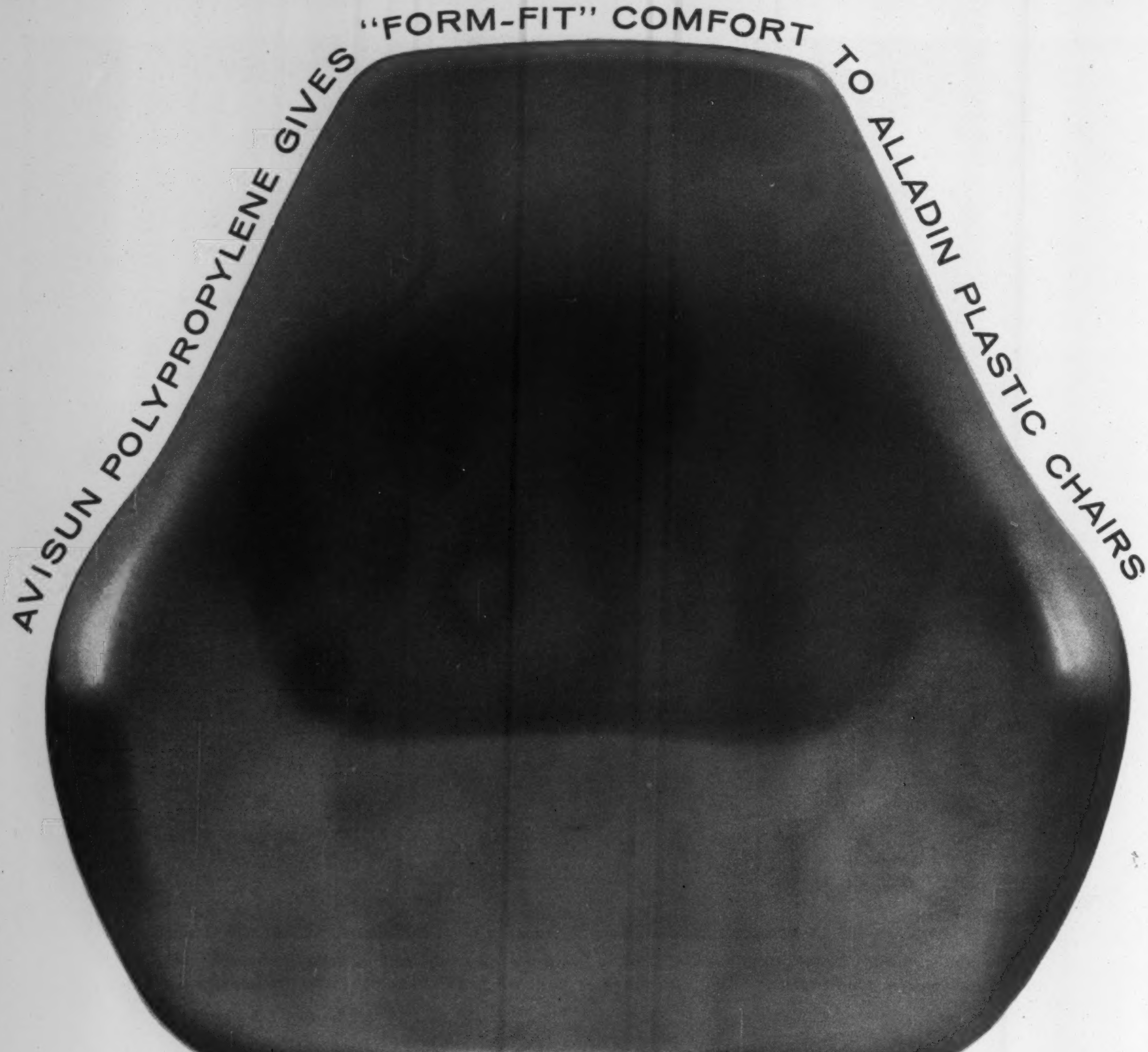
AVISUN POLYPROPYLENE GIVES "FORM-FIT" COMFORT TO ALLADIN PLASTIC CHAIRS

First Injection Molded

For this major advance in furniture making, Alladin Plastics, Gardena, Cal., uses AviSun polypropylene. Here's why: • *Amazing strength*—In Alladin's thumping, rocking torture test, AviSun Impact Grade Polypropylene outlasted all materials tested—endured up to 375 times longer. • *Supple comfort*—like that of upholstered furniture. • *Chemical and stain resistance*—to detergents, alcohols, oils, foods and cleaners—unharmed by sun and weather. • *Mold cycles*—as fast as 60 seconds with no post-mold aging. • Get the facts on how polypropylene can upgrade *your* product from: AviSun Corporation, 1345 Chestnut Street, Philadelphia 7, Pa. • In Canada: Courtaulds Plastics Canada, Limited.

*AVISUN

*Trademark of AviSun Corp.

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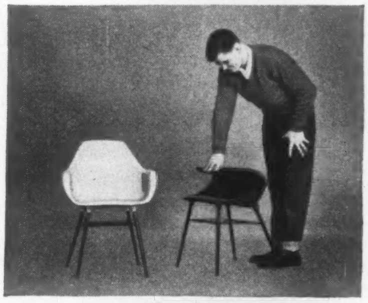
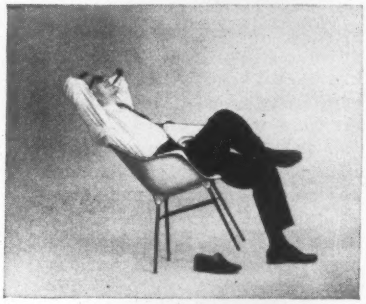
Why AVISUN polypropylene was chosen

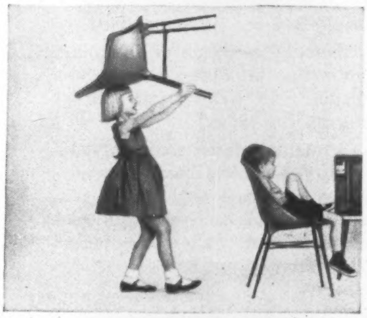


Toughness and resiliency of polypropylene give the Alladin chair the ability to shrug off all kinds of rough handling.



Polypropylene's tensile strength, inherent in the material and easily designed into the chair, was highest by actual test over all competitive materials.

Chair



Because polypropylene is lightest of the plastics, the chair can be carried about with ease by any member of the family.

MATERIALS ENGINEERING & DESIGN

(cont'd from p 132)

FLEXURAL AND COMPRESSIVE PROPERTIES AT −320 F AND 80 F

Material[a]	Filler	Compr Str, 1000 psi		Compr Mod, 10⁶ psi		Flex Str, 1000 psi		Flex Mod, 10⁶ psi	
		−320 F	80 F	−320 F	80 F	−320 F	80 F	−320 F	80 F
FEP[b]									
44%		29.95	4.0	—	—	25.6	3.74	0.68	0.19
49%		30.2	3.9	—	—	28.1	3.74	0.68	0.20
FEP[b]	20% Glass[e]	31.7	2.85	—	—	—	—	—	—
TFE[c]									
49%						30.0	3.25	0.725	0.14
50%		20.0	3.1	0.75	0.07	—	—	—	—
56%		21.2	3.2	0.80	0.12	—	—	—	—
66.2%						21.5	4.00	0.64	0.19
TFE[c]	25% Asbestos	24.2	4.75	0.71	0.1	—	—	—	—
	25% Glass	16.0	3.00	—	—	—	—	—	—
	15% Graphite[f]	17.5	3.80	0.83	0.13	—	—	—	—
Nylon 101[d]		35.25	1.10	1.70	0.6	38.0	1.075	0.85	0.42

[a] Percentages indicate crystallinity. Materials are DuPont's [b] Teflon 100X, [c] Teflon, and [d] Zytel 101. [e] Belding-Corticelli Industries processed. [f] Liquid Nitrogen Processing Corp. processed.

New Cryogenic Strength Data for Plastics

New data on the physical characteristics of some plastics that remain ductile in the cryogenic range have been determined by J. H. Lieb and R. E. Mowers, Materials Engineering, Rocketdyne, Div. of North American Aviation, Inc.

The new information on the compressive and flexural strengths and moduli of TFE and FPE fluorocarbons, and Nylon 101 is a continuation of work that Lieb and Mowers described in M/DE, July, p 107. The experiments are part of a cryogenic test program sponsored by the Directorate of Rocket Propulsion, Air Force Flight Test Center, Edwards Air Force Base.

The data given in the accompanying table compare stress at −320 F and room temperature (70 F) to show the dependence of these mechanical properties on the plastics' crystallinity. Crystallinity was measured by surface hardness tests, x-ray diffraction and specific gravity measurements. Although the cryogenic data were spread somewhat, the stated values are representative.

The values given for flexural and compressive strengths at room temperature are those for maximum fiber stress at 5% and less than 10% strain, respectively.

Cylinder Materials for Aluminum Engines

The growing importance of aluminum in small industrial and marine engines and in compact cars has stimulated interest in one of the major materials problems: giving cylinder bores and pistons greater wear resistance than that of cast aluminum.

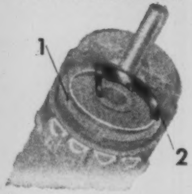
Conventionally, cylinder walls are hardened by chromium plating, by spraying with molybdenum or molybdenum and steel, or by inserting iron sleeves.

(continued on p 156)

For extreme environments!
I-S
MICRO-PROCESSED
BERYLLIUM COPPER
springs
MARKITE POTENTIOMETER

– meet these tough MARKITE 'specs'!

THE 'HEART' OF THE MARKITE POTENTIOMETER



1. A potentiometer element — embodying resistance track and take-off track of conductive plastic co-molded to an insulator base. 2. An I-S cantilever dual spring (with precious metal wipers); maintains contact with conductive tracks even under 70g vibration at 5-2000 cps, 100g shock and 100g acceleration!

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Two new approaches to the problem—1) using aluminum for both pistons and cylinder bores, and 2) transplant coating the bore with iron—were presented at this year's summer meeting of the Society of Automotive Engineers at St. Louis in June. Also discussed were the problems encountered in chromium plating aluminum cylinders.

Aluminum cylinders, pistons

Uncoated aluminum cylinder bores, used with either bare or coated aluminum pistons, are being investigated by Aluminum Co. of America's Development Div. Engine Laboratory. According to N. W. Smith, their work has helped define the problems involved with aluminum cylinders.

In the Alcoa studies, approximately 106 combinations of piston and cylinder materials were tested in single and multicylinder two and four-stroke engines. A variety of aluminum alloys were used for the cylinders. Both bare and coated pistons were tested. Coating materials included: electroplated chromium, nickel, iron, and cadmium; sprayed molybdenum, steel, and high-silicon aluminum; immersions of tin, lead and nickel; and hard annealed coatings impregnated with various scuff-resistants.

Some of the conclusions reached in the program are:

1. Wear rates of aluminum alloy cylinders are comparable to those of commercial cylinder and cylinder liner materials.

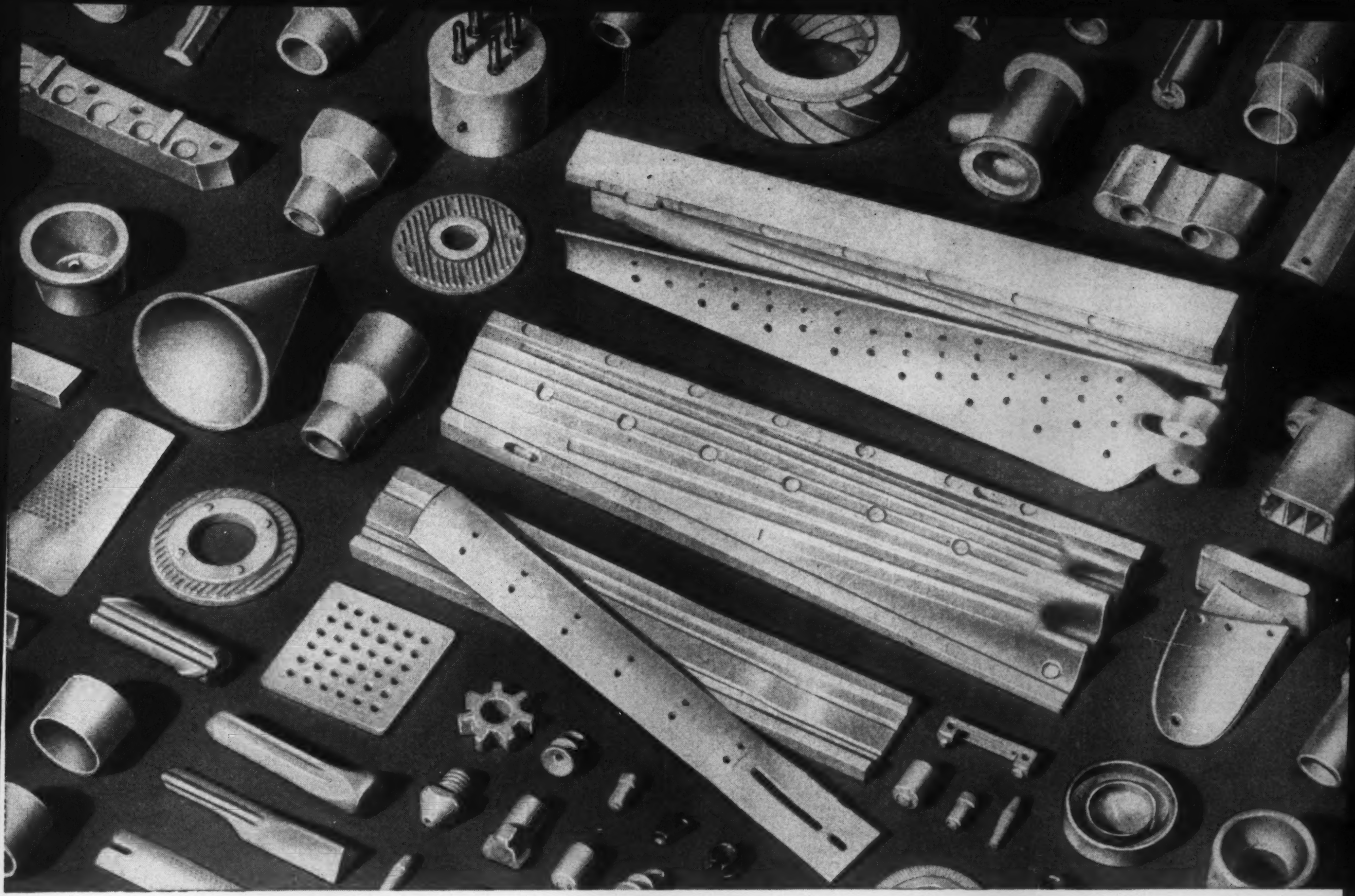
2. Elimination of scuffing is of prime importance. Both cold and hot scuffing are a function of the compatibility of piston and cylinder materials and the lubricant used.

3. Choice of cast iron or aluminum cylinders has an insignificant effect on piston ring wear regardless of plating on the rings.

4. Chromium-plated and molybdenum-sprayed pistons have been successfully combined with sand cast, permanent mold cast, and die cast aluminum-silicon alloy cylinders ranging from 6 to 23% in silicon content.

5. Higher silicon levels improve wear resistance when dirt is introduced into the cylinder.

6. Success with uncoated cylinders



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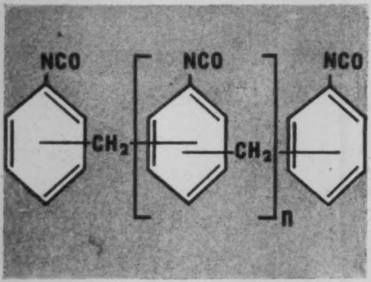

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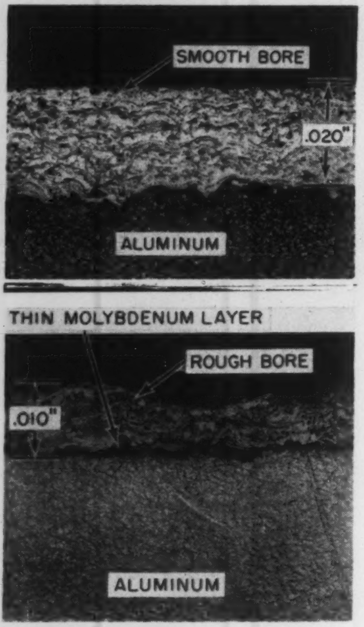
MATERIALS ENGINEERING & DESIGN



***Transplant coat** has a smooth bore surface and rough undersurface that bonds tightly to the aluminum (top). "Spraybond" bore surface is rough, and a thin molybdenum layer formed between the coating and the aluminum further weakens bond (bottom).*

and pistons and has been limited, although compatible pistons and cylinders can be made with various alloys.

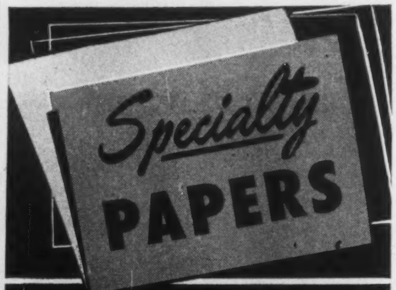
Transplant coating with iron

While Alcoa is concentrating on aluminum cylinders and pistons, National Lead Co. has developed a new lining method to improve cylinder wear resistance.

A. F. Bauer described the combination sprayed and die cast coating for 1) liners for water-cooled engines, and 2) cylinder barrels for air cooled engines.

In the process, ferrous material is first sprayed onto the core of the casting die. It is subsequently transferred to the casting when the injected aluminum (or liner metal) shrinks onto the rough outside of the sprayed coat. Because of the expansion differential, the protective coat stays with the casting and creates a taper-free bore of extremely high smoothness and accuracy.

(continued on p 160)



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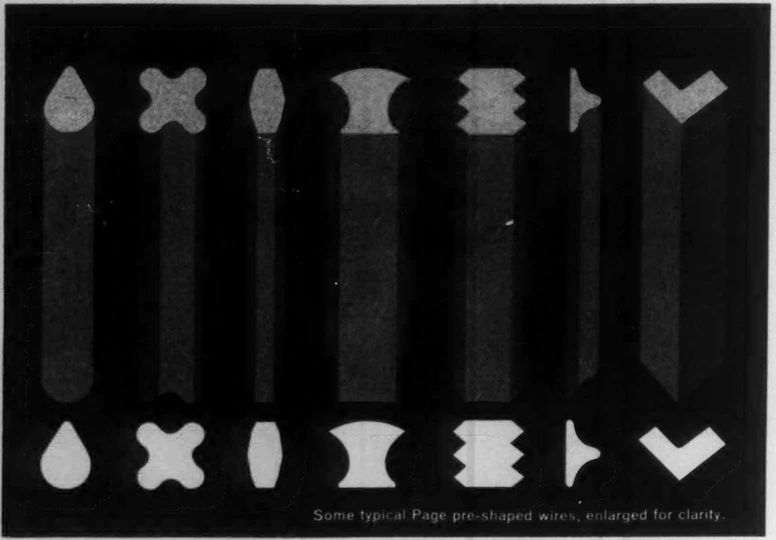

Some typical Page pre-shaped wires, enlarged for clarity.

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MATERIALS ENGINEERING & DESIGN

Although National Lead's tests were run on ferrous coatings 0.020 in. thick, the coating can be produced in any thickness with controlled porosity. Any material that can be sprayed can be used. The 0.020-in. thick coat gave excellent results in the tests and is a fair compromise between economy and strength.

Bond strength is said to be high because the rough face of the sprayed metal creates a strong bond with the aluminum.

In shear tests, an average shear strength of 14,000-15,000 psi was obtained, and the line of failure was in the base aluminum.

In tensile tests, specimens 0.10 in. and 0.030 in. thick failed at 4000 psi and 4200 psi respectively. Failure occurred in the coat.

Mr. Bauer reports that transplant coated die cast aluminum cylinders for small air cooled engines are expected to be commercial this year.

Hard-chromium-plated bores

L. W. Raymond and A. K. Wood of Superior Plating Co., Fairfield,

This platen press is being used to cure a honeycomb sandwich structure. Steam will be circulated through the bottom platen with the top platen applying the pressure necessary to insure proper bonding of the sheet aluminum and honeycomb material. The press is one of the test machines in Boeing Airplane Co.'s metal bonding pilot plant at Wichita, Kan. The plant enables engineers to resolve metal bonding production problems by simulating actual production processes.

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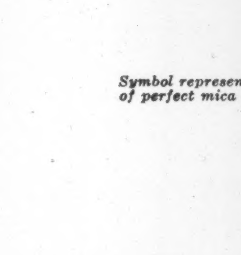

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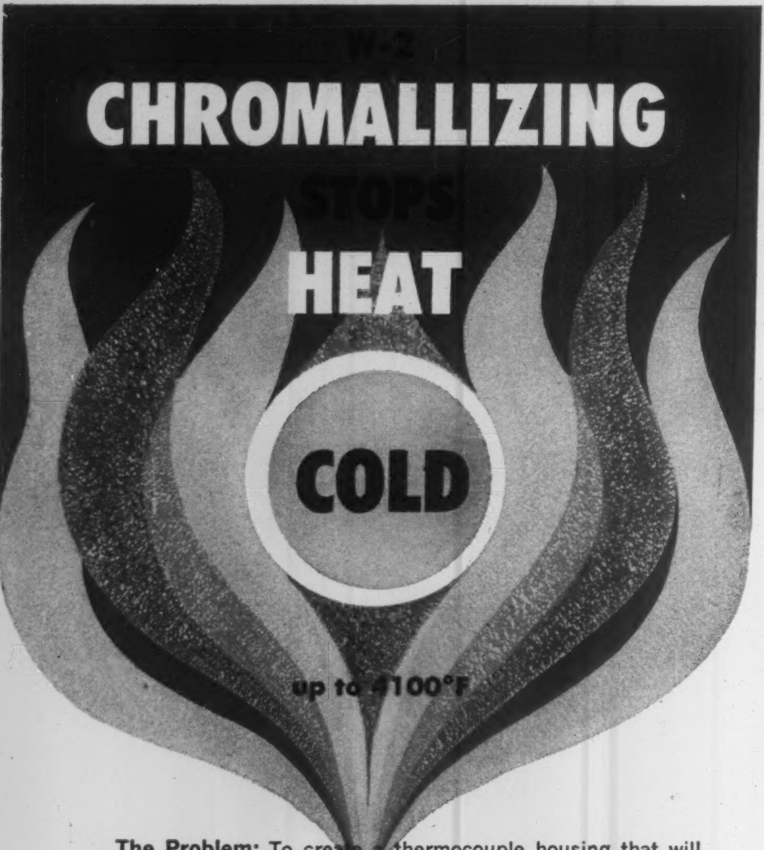

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The solution: A CHROMALLIZED molybdenum thermocouple housing. This housing withstands temperatures up to 4100°F. Other applications are structural parts for re-entry vehicles, high temperature testing grips, and ramjet engine components.

What is Chromallizing?
A proven process for diffusing chromium and other elements into the surface provides an alloy case which is integral with the base metal. It can't peel or flake. the chromium and other elements diffuse uniformly into recesses, pores, cracks and even blind holes.

CHROMALLIZING processes are also being used to protect superalloys for jet engine parts and to protect ordinary steel against wear, oxidation and corrosion.

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Conn., said that aluminum is not an easy metal to electroplate with chromium.

First consideration should be given to the choice of alloy. At present, chromium is being successfully plated on 355, 356 and 380 aluminum. All of these are copper, silicon and magnesium-bearing alloys.

Each of these elements can interfere with the plating cycle. In the "Zincate" process, for example, chromium is deposited on a very thin, intermediate layer of pure zinc. All traces of the alloys must be removed from the aluminum surface before the zinc is applied.

Silicon and magnesium are relatively easy to remove, but copper is a problem. Any copper in excess of the amount soluble in aluminum (5.65%) creates plating problems by not accepting the zinc.

A second source of difficulty is improper solution and/or precipitation heat treatment. Specifically the following alloys and heat treatments have been most successful: 380-T51, 356-T71, and 355-T71.

Other factors that demand critical attention are:

1. Porosity, which causes plating blisters by leaching out the cleaning and plating solutions. Also, sharp chromium nodes tend to build up around the cavities and subsequently scratch the piston.
2. Excessive die lubricant which covers areas to be plated.
3. Cylinder finish before plating which should be smooth enough to give predictable end results and not rough enough to scuff the piston.
4. Caustic materials, which form metallic soaps and attack aluminum.

New Property Data on 752 Columbium Alloy

A columbium-base alloy containing 5% zirconium and 10% tungsten combines high strength at elevated temperatures with excellent ductility at room temperature, a recent investigation shows.

Tests of the alloy, called Haynes alloy Cb-752, were conducted by Union Carbide Metals Co. The tests indicate that the amounts of tungsten and zirconium increase strength by solid solution hardening but not

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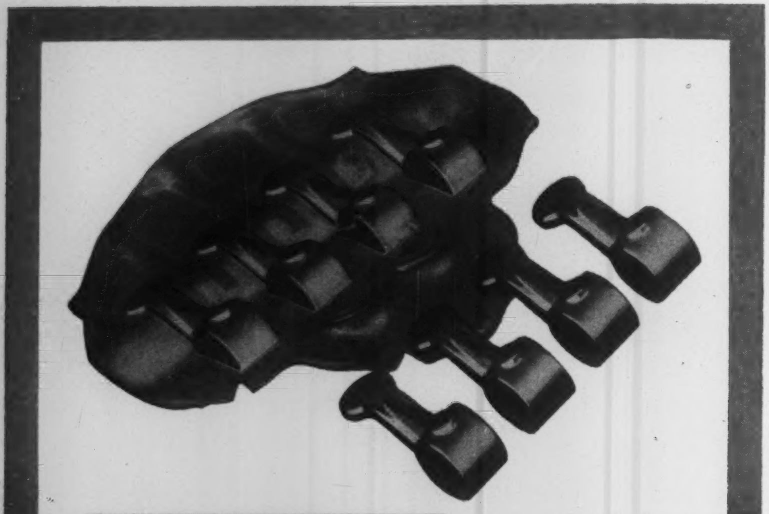

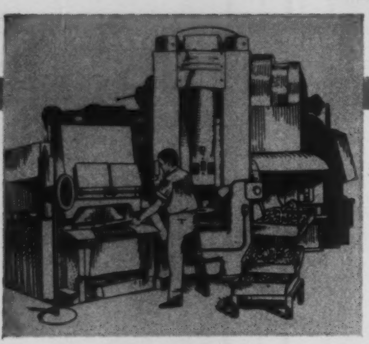

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[redacted]

to a level that would impair ductility at room temperature.

The tests, reported by C. R. McKinsey, A. L. Mincher, W. F. Sheely and M. Schussler, included determination of oxidation behavior and mechanical properties, and a study of bar and sheet production techniques.

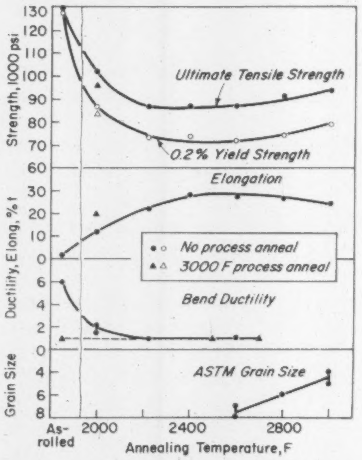
Oxidation resistance moderate

No serious oxidation problems were encountered in manufacturing bar stock, the exposure to high temperature being brief. Billets were machined from ingots, induction heated in argon to 2500-2600 F, and extruded at a 3:1 or 4:1 ratio.

Swaging presented a greater oxidation problem which was successfully overcome by heating the bar in molten glass.

In making sheet stock, annealed slabs were repeatedly rolled at temperatures of 2000 F and higher. Considerable oxidation occurred. The oxidation rate of 752 alloy at 2000 F, as shown by metal loss and depth of contamination, falls between those of two other high strength alloys, D-31, and F-48. For example, the 752 alloy lost approx 0.01 in. per side and was contaminated to a depth of 0.04 in. after 24 hr exposure at 2000 F.

Although there are indications that some surface oxidation can be



1 *Effect of heat treatment on room temperature properties of electron beam melted sheet, cold rolled to 0.030-0.040 in.*

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In this family of high-nickel alloys, you'll find metals that provide good strength and long life at temperatures from 1200 to 2300° F. You'll find alloys with remarkable combinations of properties—properties needed to withstand oxidizing and reducing environments and carburizing and nitriding atmospheres.

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tolerated without impairing fabricability, oxidation protection should be provided while working at high temperatures.

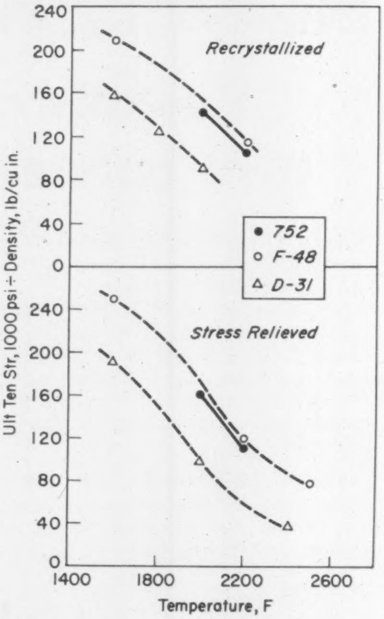
Tensile properties good

After cold rolling, strength of the alloy sheet was high and ductility was rather low. However, stress relief treatments at temperatures as low as 2000 F increased ductility at the expense of strength, as shown in Fig 1. Maximum ductility and minimum strength are obtained by heat treating at 2600 F. Some secondary hardening at higher annealing temperatures was also noted.

Bend ductility is improved when the alloy is process annealed at 3000 F prior to rolling, and is retained after heat treatment at 2500 or 2700 F. Also, the tensile ductility of a process-annealed specimen given a final stress relief at 2000 F is nearly twice that of a specimen that has not been recrystallized.

Recrystallization starts at about 2400 F and is completed to a fine grain size at 2600 F.

The strength-temperature variation shown in Fig 2 is typical of



2 *Strength-weight ratios compared for three alloy sheets in the stress relieved and recrystallized states.*

Tool Steel Topics

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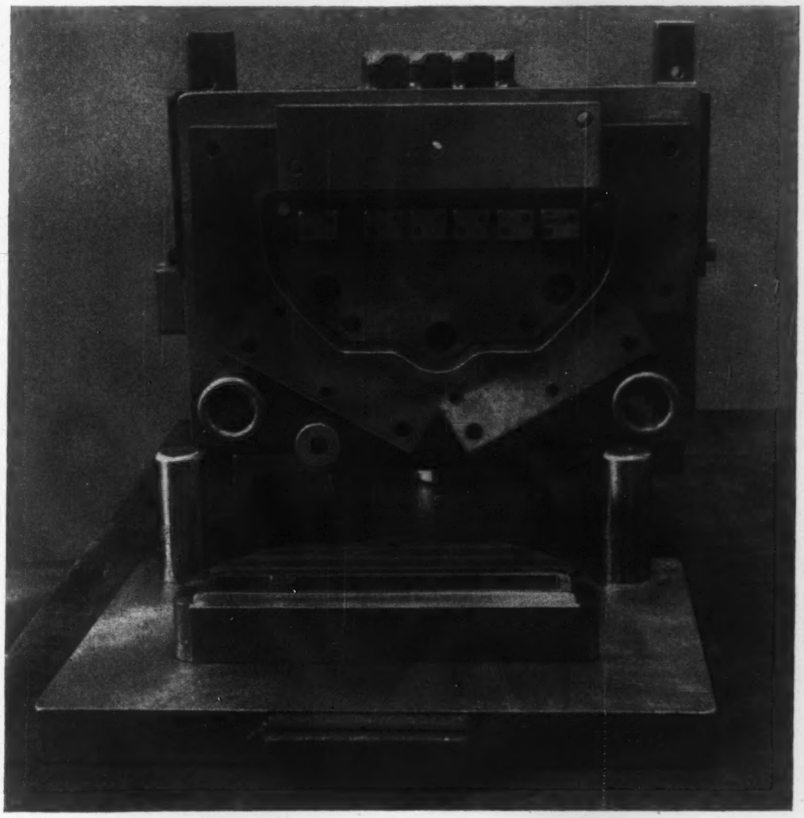
Export Sales: Bethlehem Steel Export Corporation



Bethlehem Brake Die Tool Steel Forms Vacuum-Cleaner Base Plate

At Remmele Engineering, Inc., St. Paul, Minn., they needed a tool steel with high strength to handle a difficult forming operation on sheet steel. The part, a base plate for a vacuum cleaner, was produced by a die made of Bethlehem Brake Die tool steel.

Engineers at Remmele liked Brake Die's well rounded combination of fine mechanical properties. They also found it a time saver because it machined so readily. Best of all, it produced thousands of pieces before slight redressing was required.

This tool steel requires no heat-treatment

Brake Die is ideal for intricate bending and forming dies because it combines high wear-resistance with high strength. It requires no additional heat-treatment because it is furnished in the heat-treated condition, ready for machining into a finished die. Brake Die is quenched and tempered in our shop to develop its superior properties. Then we straighten it mechanically and give it a stress-relief-anneal to remove straightening stresses.

Your Bethlehem tool steel distributor has Brake Die on hand in many sizes and sections, ready for prompt delivery. Give him a call today.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

For Uniform Service from Tools, Control the Surface Chemistry

One of the most difficult problems in the use of tools is non-uniformity of service life. Absolute uniformity in production from all identical tools is not expected. But wide variations in service life from one tool to another, or from one lot to another, present a real problem.

It has been found that the most frequent cause of non-uniform service is the variation of chemistry on the tool surfaces. Small amounts of surface carburization or decarburization usually are unnoticed because they can be detected only by destructive testing.

Decarburization on working surfaces of tools causes a decrease of normal service life. And varying amounts of decarburization from tool to tool will cause variable decreases in service life.

Carburization, on the other hand, is not always harmful. Many tools last longer if a carburized case of the optimum depth and carbon content is present. This is true whether the carburized case is intentional, or whether it is accidentally and unknowingly present. The extent to which a carburized case either increases or decreases service life of tools must be determined by experience with the actual tools under consideration. It is therefore possible for tools with a "neutral" surface to be either better or poorer in service life than tools having a carburized case.

The surest way to provide uniform surface chemistry is to grind the tools adequately after the hardening operations. The only alternative is to be sure that "neutral" heat-treatment equipment is actually doing the expected job of providing unground hardened tools with neutral surfaces.

For more information, turn to Reader Service card, circle No. 409

LUBRICATION REPORT
(dry film coating)

Application: *Lock Part Pre-Assembly Lubrication.*
Problem: *Find a quicker, cleaner method of lasting lubrication.*
Solution: *'dag'® Dispersion 154 — diluted in equal parts with denatured alcohol.*

RESULT: *CLEANER, MORE UNIFORM, LONGER-LASTING LUBRICATION ON LOCK PARTS*

Cam retainers and disc tumblers used in American Hardware Corporation's padlocks are 1/2 by 1/4 inch brass stampings. Because of their small size, this New Britain, Conn. manufacturer has found dipping to be the most efficient method of lubricating them. Acheson's 'dag' 154 proved to be ideal for this operation. Its alcohol carrier quickly evaporates, leaving a permanent film of graphite on the parts. This microscopically thin film is deposited uniformly, adheres tenaciously, and will not rub off during lock assembly. Since it does not attract dust and discourages oxidation and corrosion of the brass parts, 'dag' 154 provides a longer, smoother operating life for the locks.

For more information on the advantages of Acheson dry-film lubricants in product design, send for your copy of Bulletin No. 435. Write to Dept. ME-91.

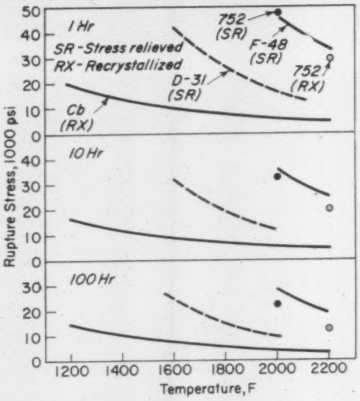
ACHESON – First name in solid lubricants for fifty-three years.

ACHESON *Colloids Company*
PORT HURON, MICHIGAN
A division of Acheson Industries, Inc.

Sales offices in principal cities.

Also Acheson Industries (Europe) Ltd. and affiliates, London, England

For more information, turn to Reader Service card, circle No. 427



3 *Comparison of stress-rupture properties of 752 alloy with those of columbium, D-31 and F-48.*

most columbium-base alloys. The strength plateau at the intermediate temperatures and the peak at about 1500 F indicate dynamic strain aging. A tensile strength of about 50,000 psi was obtained at 2000 F, and 20,000 psi at 2600 F.

Stress-rupture strength

The time dependence of strength properties is shown by the stress-rupture data in Fig 3. Tests were conducted in vacuum with stress-relieved material at 2000 F and recrystallized alloy at 2200 F. In the tests at 1 hr, 10 hr and 100 hr, elongation at rupture was greater than 20%.

ABS Sandwich Panels Insulate Freight Cars

Plastics sandwich wall construction is one of the major innovations that enable new refrigerated freight cars to maintain any temperature from −10 F to +70 F, have more cargo space, and weigh less than conventional "reefers."

The cars, redesigned and built by Pacific Fruit Express, have all-welded frames with all support members on the outside walls.

The panels consist of a liner shell of ABS polymer sandwiched over a block of expandable polystyrene insulation. The sandwich panels are 9 ft high × 42 in. wide × 6½ in. thick.

(continued on p 170)

"Black CRYSTOLON*" grain
...crystals that master lightning

Often referred to as "Black CRYSTOLON", Norton E 179 CRYSTOLON Electrical Grade silicon carbide grain is widely used in lightning arrestors — and in a steadily increasing variety of other nonlinear resistor applications in the electrical-electronics field.

These applications include protection of coils from overvoltage, protection of relay contacts, and general voltage stabilization . . . with voltage or surge control requirements ranging from thousands of amps to microamps . . . in resistors ranging in volume from thick arrestor blocks to paper-thin varistors.

To control its semiconduction properties, E 179 differs from regular CRYSTOLON silicon carbide grain by the addition of alumina. But the most important control of E 179 is constant control through each step of manufacture, from electric furnace to shipping drum. Accurate, duplicable grain impedance (resistivity) is assured by careful furnacing, grain processing, sizing, blending and surge testing.

In loose pack or ceramic bonded form, E 179 CRYSTOLON grain has the nonlinear current-voltage relation $I = AE^n$, where "A" and "n" are constants. For loose grain "n" may be as high as 10; for bonded grain it is usually between 3 and 7.

For surge tests, standard 280 ampere pulses are passed through a column of compressed E 179 CRYSTOLON grain, 1" diameter x 1" long. Voltage across the cell is measured in kilovolts per inch. E 179 CRYSTOLON grain is available in sizes of 60 to 240 mesh, covering a surge test range of 1.6 to 13.0 KV/inch.

For further facts, contact NORTON COMPANY, Refractories Division, 348 New Bond Street, Worcester, Mass.

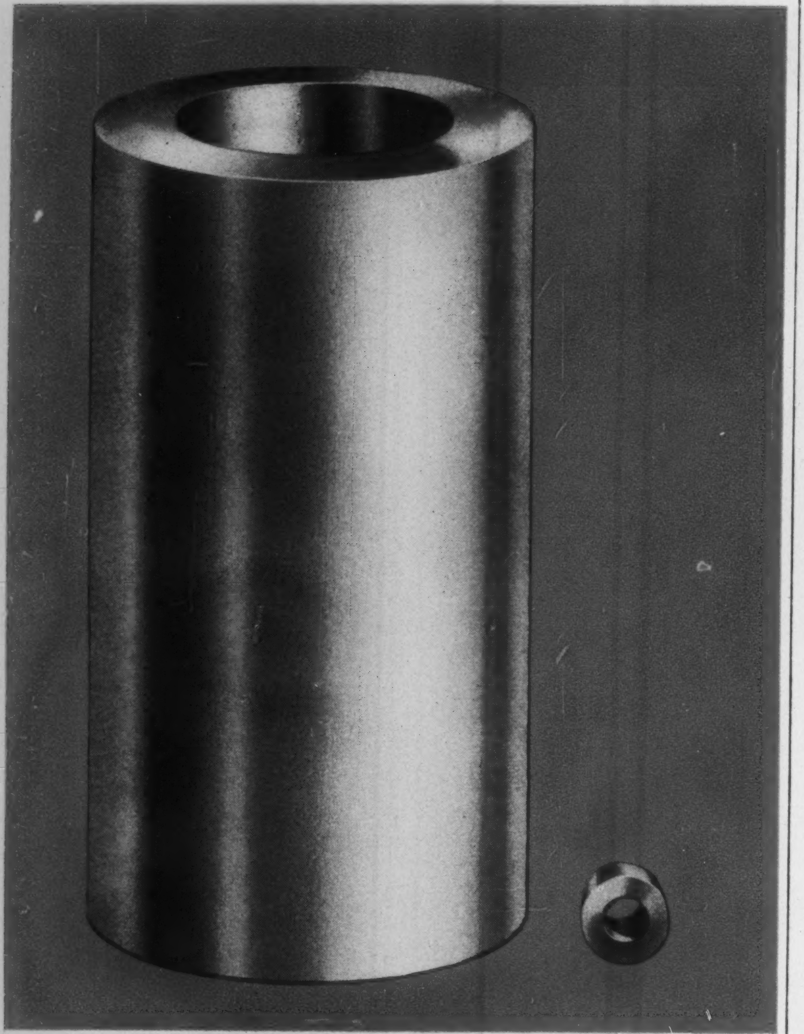
*Trade Mark Reg. U. S. Pat. Off. and Foreign Countries.

NORTON

REFRACTORIES

Crystallizing ideas into products

For more information, turn to Reader Service card, circle No. 356



In Using Powdered Stainless Steel . . .

WHETHER YOUR PART IS LARGE OR SMALL

HIGH GREEN STRENGTH IS IMPORTANT!

VASCO PREALLOYED METAL POWDERS

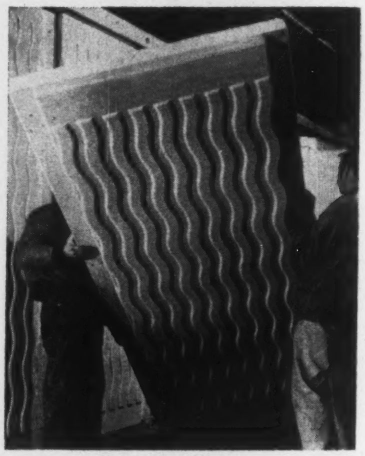
You get the all-important high green strength you need in improved VASCO stainless steel powders, *prealloyed for performance*. Better molding qualities make our stainless powders now almost as easy to press as simple iron powders . . . provide greater green density . . . permit the manufacture of more intricate parts . . . and afford better strength and ductility as well. Sintering conditions are within the range of standard equipment. Write for Data Sheets!

VA

Vanadium-Alloys Steel Company
POWDER METALLURGY DEPARTMENT
LATROBE, PENNSYLVANIA

For more information, turn to Reader Service card, circle No. 454

MATERIALS ENGINEERING & DESIGN



***Installing insulation** in a new refrigerated freight car. The panels are made from ABS polymer sheet bonded to expandable polystyrene. Corrugations permit passage of cold air around the cargo.*

The sheet plastic used is Cycolac, produced by Marbon Chemical Div., Borg-Warner Corp. According to Marbon, the panels have unusual shock and impact resistance at subzero temperatures, reliable dimensional stability, and high moisture resistance.

The panels are vacuum formed by Landis Industrial Co., Inc. and incorporate a modified S-curve corrugation that permits movement of cold air around closely packed cargo. The curve is so designed that containers cannot catch and hang on the corrugations during loading.

Each of the shells has a stepped edge for fastening it to the car's steel structure individually. Since the panels are not fastened together, expansion and contraction is possible. Space between the panels is covered with a matching plastic strip.

WATCH FOR 'SELECTOR'

The fifth edition of M/DE's *Materials Selector Issue*—revised, expanded and updated—will be published the middle of next month. Among the additions are a price comparison chart and a new section on composite materials. The issue also features new data and a completely new format for the section on fabricated and mill forms.

REVCO

ULTRA-LOW TEMPERATURE CABINETS

TEMPERATURES
TO
−140°F.

for

- **Research**
- **Storage**
- **Seasoning**
- **Testing**

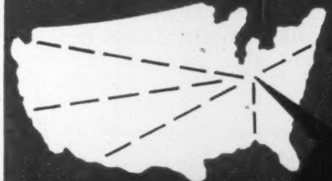
Seven Revco cabinets, both chest and upright styles, are available. Capacities range from 1.5 to 6 cu. ft. in chests and to 22 cu. ft. in uprights. Units provide temperatures to −140° F. controllable within ±1°. Optional accessories are offered. Immediate delivery on all units.

For your FREE copy of the helpful folder, "Selecting a low temperature cabinet," write Revco, MDE-91.

Industrial Products Div.,
REVCO INC.
Deerfield, Michigan
Setting Trends in Refrigeration Since 1938

For more information, turn to Reader Service card, circle No. 353

FROM AROUND THE NATION



Leading Manufacturers Beat a Path to
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. . . for difficult-to-extrude aluminum shapes and for new developments of extruded aluminum. For certain needs, G.E.I.'s customers send their own aluminum parts to be anodized, machined, finished or for additional fabrication. Whether your needs are standard or special, G.E.I. can save you time, material and money. Write for catalog.

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OVER 500 STOCK DIES READY TO FILL INDUSTRY'S NEEDS

- Trim Sections
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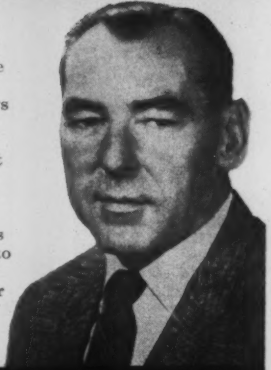
For more information, turn to Reader Service card, circle No. 363

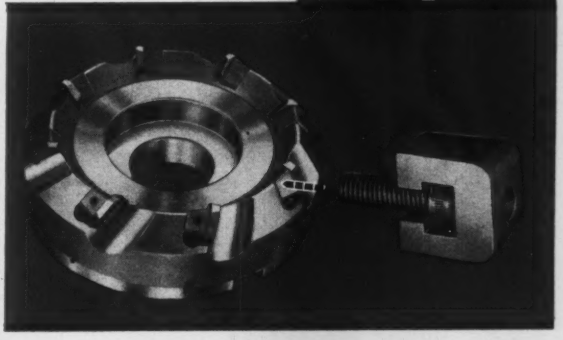
Casting Engineers

Produced a Precision Component that's stronger . . . eliminates tedious assembly . . . and cuts costs 30%

Says John Begle
Vice President of Manufacturing Futurmill Inc.

"In redesigning the blade-locking wedges in Futurmill indexable milling cutters, we discarded all preconceived ideas and looked for new ways to reduce cost and improve quality. Casting Engineers produced an investment cast wedge that reduces finish machining, simplifies assembly, improves dimensional accuracy, is far stronger, has its part number cast right into its body . . . yet costs 30% less than our old design. Our customers like it . . . and so do we."





MINICAST Machine Tool Parts Add Quality at Lower Cost

The new design wedge, investment cast in strong chrome-vanadium steel, requires only one-step light grinding. The retaining socket cap screw drops into an integrally cast recess. The previous design called for five separate machining operations, plus three-part assembly.

Whether your application requires our high-volume MINICAST process for relatively small parts, or the newer MONOCAST ceramic shell technique for larger pieces, Casting Engineers guarantees maximum production efficiency at lowest cost.

A competent staff of design, mechanical and metallurgical specialists makes Casting Engineers your best single supply source for castings for any application.

Cut your production costs by specifying investment castings. This new brochure tells you how, Write for your free copy now.

MINICAST
MONOCAST
Casting Engineers
PLANTS IN CHICAGO AND NEW YORK CITY
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2322 N. BOSWORTH AVE. • CHICAGO 14, ILL.
BUckingham 1-5940

For more information, turn to Reader Service card, circle No. 471

Famous BUTLER building panels formed from BONDERIZED, color-coated hot-dip galvanized coil

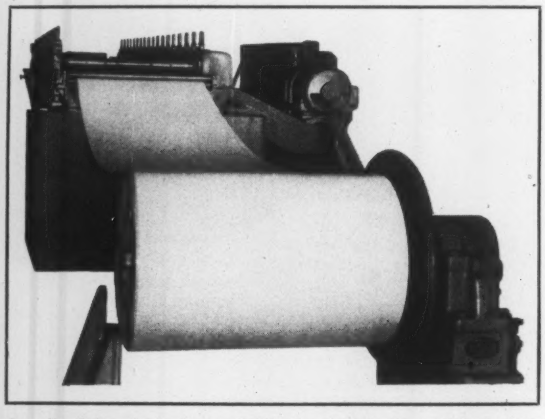
Butler Manufacturing Company building panels, Bonderite-treated and with baked-on finish, are easily and quickly erected.

BUTLER PANELS LOOK BETTER LONGER! Those attractive Butler buildings, with their strong ribbed panels and handsome colors, will retain their appearance through many years of weather and hard service.

Butler panels are formed from Bonderized, pre-finished hot dip galvanized stock. This combines the corrosion-resistance of hot dip galvanized with the advantages of baked-on finish, over Bonderite, to produce panels with vastly increased durability.

Bonderite is the key to the superior adhesion which allows forming *after* paint coating, without damage to the finish on Butler panels. Bonderite produces a close, small-grained, nonmetallic crystalline coating integral with the metal itself—a perfect base for any finish.

For the finest, most durable protective finish on your product, make the choice that quality manufacturers like Butler have made. Insist on Bonderite under the finish!



A coil of Bonderized, pre-finished galvanized steel feeds into roll former at a Butler plant.

PROTECTED BY Bonderite PARKER RUST PROOF CO. QUALITY CORROSION RESISTANT

Parker **Rust Proof Company**
2173 E. MILWAUKEE, DETROIT 11, MICHIGAN

BONDERITE corrosion resistant paint base • BONDERITE and BONDERLUBE aids in cold forming of metals • PARCO COMPOUND rust resistant • PARCO LUBRITE—wear resistant for friction surfaces • TROPICAL—heavy duty maintenance paints since 1883

Since 1914—Leader in the field

*Bonderite, Bonderized, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.

For more information, turn to Reader Service card, circle No. 355

What's new IN MATERIALS

(cont'd from p 15)

TABLE 2—MC NYLON VS OTHER NYLONS

Property	ASTM Method	MC Nylon 901	Type 6	Type 6/6
PHYSICAL PROPERTIES				
Specific Gravity	D792	**1.16**	1.12-1.15	1.14-1.15
Water Absorption, %				
Equilibrium in Air	D570	**0.9**	1.5-2.0	1.5
Saturation	D570	**5.5-6.5**	8-10	7-9
Coef of Lin Ther Exp, 10^{-5} per °F	D696	**5.0**	5.0	5.5
Melting Point, F	D569	**430**[a]	432 ±9	496 ±9
Heat Distortion Temp, F				
264 Psi	D648	**400**	130-175	200
66 Psi	D648	**425**	345-365	360
Flammability, ipm	D635	**Self-ext**	Self-ext	Self-ext
MECHANICAL PROPERTIES				
Tensile Strength, 1000 psi	D638	**11-14**	9-12	9-12
Ten Mod of Elast, 10^5 psi	D638	**3.5**	3.5	4.0
Elongation, %	D638	**20-30**	25-250	25-200
Tensile Impact Strength, ft-lb/sq in.		**80-100**	40-150	90-180
Shear Strength, 1000 psi	D732	**10.5-11.5**	7.6-8.2	9.6
Stiffness, 10^5 psi	D747	**2-4**	2.3-3.5	2-4
Hardness (Rockwell)	D785	**R118**	R111-118	R110-120
Deformation under load (122 F, 2000 psi), %	D621	**0.5-1.0**	1.0-2.5	1.0-3.0
ELECTRICAL PROPERTIES				
Dielectric Strength (short time), v/mil	D149	**500-600**	300-400	300-400
Dielectric Constant				
60 Cps	D150	**3.7**	5.0-14.0	4.1
10^3 Cps	D150	**3.7**	4.9-10.1	4.0
10^6 Cps	D150	**3.1**	4.0-4.7	3.4
Power Factor				
60 Cps	D150	**0.02**	0.06-0.10	0.014
10^3 Cps	D150	**0.02**	0.06-0.11	0.02
10^6 Cps	D150	**0.02**	0.04-0.13	0.04

[a] Gel temperature.

mold for the same part would cost between $100 and $500.

The process has been announced by Polymer Corp., Reading, Pa., which has obtained exclusive rights to the process from Monsanto Chemical Co. Monsanto holds patents on the basic chemistry. Polymer Corp. will both cutom-cast parts to specifications, and supply standard mill shapes. It has designated the material made by the process as MC nylon.

Designed for large parts

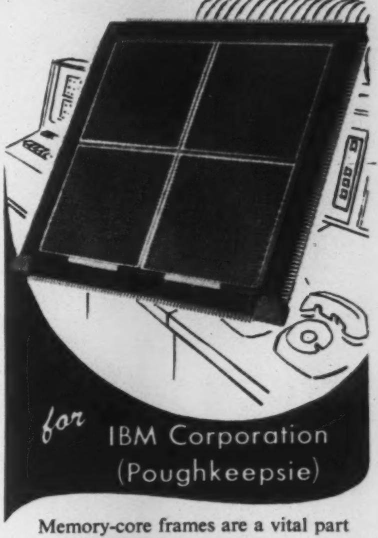
The process is primarily designed for producing large and complex shapes, or small parts that can be economically cut from cast profiles. For small parts it is not competitive with injection molding, since minimum polymerization time (or cycle time) in the mold would be at least 5 min for small parts, as compared with 15-30 sec in injection molding cycles. But for larger parts (1 lb and up) injection mold costs increase rapidly, production rates decrease, and volume requirements (for mold amortization) usually increase.

According to Polymer Corp., since the process is similar in both

example...

FIBERITE

at work in
computer
memory frames



for IBM Corporation
(Poughkeepsie)

Memory-core frames are a vital part of IBM's fabulous computers.

These frames hold and protect the tiny "memory units" which store information for processing.

IBM Poughkeepsie, working with Fiberite Corporation, specified a reinforced plastic frame material with these characteristics:

- The ultimate in dimensional stability under widely varying atmospheric conditions
- High impact and flexural strength
- Minimum shrinkage values
- High dielectric strength
- High heat resistance
- Good molding characteristics
- Automatically preformable

With Fiberite compound F.M. 4005, the exact formulation was achieved through the intense cooperation of Fiberite research engineers and their counterparts at IBM. Results have been called "outstanding."

Your firm, too, can benefit from Fiberite's experience, skill and imagination. Special applications to fit special problems are Fiberite's stock-in-trade.

Why not get complete information on how Fiberite can work for you. Write today for details, and ask also for your free catalog. Today is not too soon!

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MOLDING COMPOUNDS

THE FIBERITE
CORPORATION
Dept. ME-9
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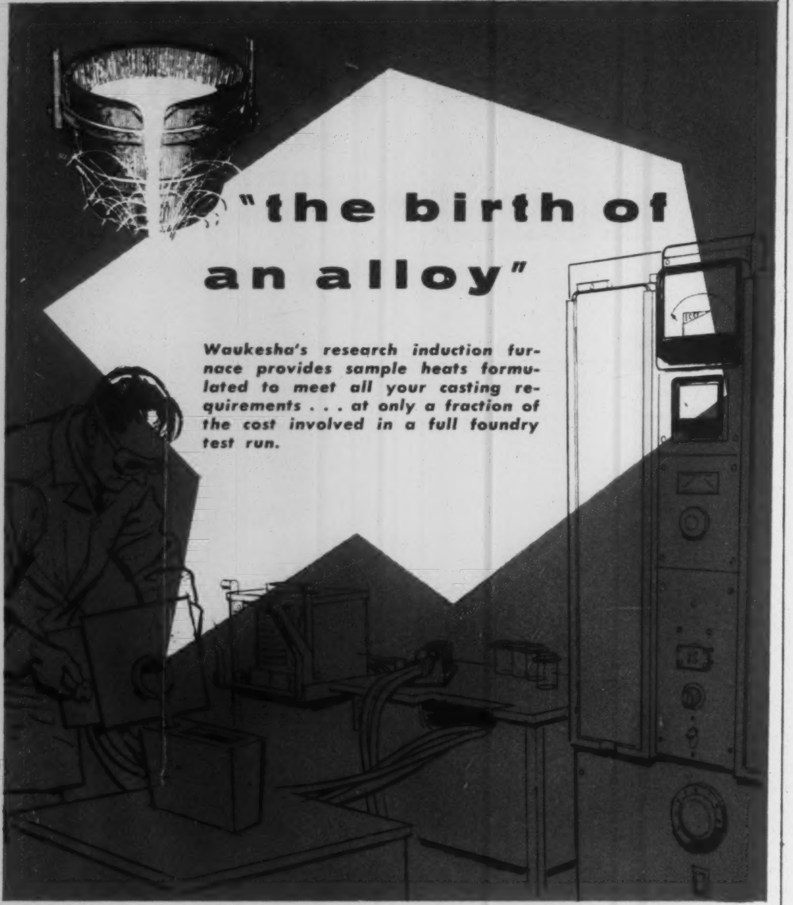
Winona, Minnesota

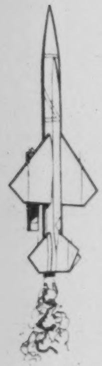
SALES OFFICES IN PRINCIPAL CITIES

For more information, circle No. 423


"the birth of an alloy"
Waukesha's research induction furnace provides sample heats formulated to meet all your casting requirements . . . at only a fraction of the cost involved in a full foundry test run.

WAUKESHA CASTINGS

From created alloys . . .



Pressures . . . corrosion-resistance . . . stability under extreme temperature variables . . . increased tensile strengths . . . only castings of created alloys can fulfill all the precise requirements of space-age technology. In less than a decade, Waukesha Foundry Company has created 5 corrosion-resistant non-galling metals.

From blueprint to finished casting, Waukesha follows your precise requirements. Facilities include "Spectrometer" control with each heat, pilot plant facilities, sand, shell and ceramic-type moldings, fully equipped finishing and polishing shop. The metallurgical staff assigned to create the alloy for your product offers over half a century of experience with created metals.

Where precision engineered castings are an absolute requirement, call on Waukesha.

Waukesha Foundry Company

WAUKESHA FOUNDRY CO.
Dept. F-37, Waukesha, Wis.
Manufacturers of corrosion-resistant castings, inclusive of non-galling alloys, Stainless Steel, Waukesha Metal, Monel, Pure Nickel, Inconel, Ni-Resist, plus special Nickel-Chromium Alloys for specific applications.

For more information, turn to Reader Service card, circle No. 424

technique and costs to metal casting, MC nylon should open up new markets for large parts in heavy industry where high tooling costs and processing limitations of conventional molding methods have made nylon's use impractical. Such parts may be used in equipment for steelmaking, railroads, paper converting, materials handling, mining and construction.

Properties somewhat different

Table 2 compares properties of MC nylon with those of type 6 and 6/6 nylon. According to these data, the most significant differences in properties MC nylon displays are: 1) substantial increase in heat distortion temperature, 2) somewhat better deformation under load (indicating good compressive creep resistance), 3) reduced moisture absorption, and 4) generally improved electricals. An interesting point to note is the lack of a clear-cut melting point. MC nylon gels rather than melts, at 430 F.

Other outstanding properties, according to Polymer Corp., include excellent resistance to fatigue under cyclic or vibration-induced stressing, and excellent wear resistance (particularly to the sandblasting type of abrasion).

The reason for the differences in performance of the new nylon is not clear, according to Polymer Corp. Although produced from a type 6 monomer, the final polymer has its own distinct properties. Contributing factors may be differences in crystallinity and the facts that casting results in essentially no internal stresses in the final part.

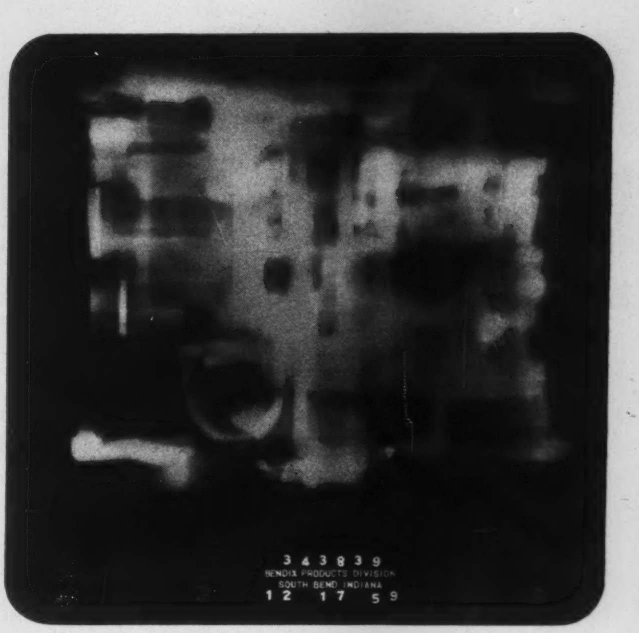
Other types of MC nylon, such as a high impact grade, are under development and may be announced soon.

Sizes, tolerances, detail

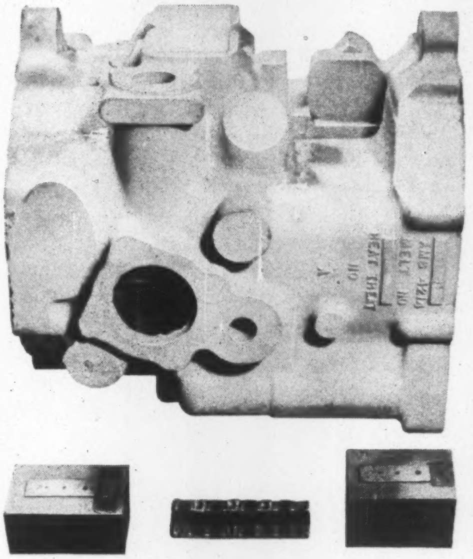
At present, there is much art to the monomer casting process, ac-

ITS JOB:

Watching the diet of hungry jets



Radiograph of casting showing soundness and condition of internal passages.



Casting for jet engine fuel control valve made by Bendix Products Division, South Bend, Indiana.

A maze of passages and channels, this intricate casting becomes a jet fuel control valve. Bendix checks the soundness of the body and clearness of the passages with Kodak Industrial X-ray Film.

FEEDING 2500 gallons of fuel an hour with precise control is the task for this casting. It will be machined to infinitesimal tolerances and then precision fitted with valves and controls. Is the casting sound? Are wall thicknesses correct? Are internal passages clear? Bendix Products Division, South Bend, Indiana makes sure with radiography.

Radiography is the one means of non-destructive testing that not only inspects internal conditions but provides a record of the findings.

Producers of castings and makers of welded products use radiography to make sure that only quality work is delivered—a means of building a good reputation and increasing business.

Radiography may be important in your work, too. Why not discuss it with an x-ray dealer—or write us for a Kodak Technical Representative to call?

NOW . . . Ready Pack in ROLLS and SHEETS

Kodak Industrial X-ray Film, Types AA and M, in 200-ft. rolls (16mm, 35mm, 70mm) and sheets (8 x 10, 10 x 12, 11 x 14, 14 x 17).

- No darkroom loading—film sealed in a light-tight envelope.
- Just place Ready Pack in position and expose.
- Film protected from dust, dirt, light and moisture.
- In the darkroom—remove film from envelope and process.

EASTMAN KODAK COMPANY

X-ray Sales Division **Rochester 4, N.Y.**

Kodak
TRADEMARK

For more information, turn to Reader Service card, circle No. 332

Are Small Precision Metal Parts Disturbing Your Sleep?

The manufacture of small precision metal parts—in large volume—can sometimes take on the aspects of a bad dream. The problems are frequently numerous and complex. Their solution calls for specialized experience.

Torrington is the leading specialist in this field. We have the skill, engineering experience and manufacturing facilities to produce—at high speed and economical cost—a tremendous variety of small metal parts of exceptional precision and uniformity.

If you have such parts to be manufactured in large quantities, why not let Torrington solve your entire problem? Write us for complete information—or better yet, send us a blueprint, and we'll be prompt in making our recommendation.

progress through precision **SPECIAL METAL PARTS**

THE TORRINGTON COMPANY Torrington, Connecticut

For more information, turn to Reader Service card, circle No. 348

cording to Polymer Corp. But here is how the process shapes up from the design standpoint so far:

1. *Size limitations*—Certain profiles have been cast up to 4 ft long. Plates weighing over 800 lb have been cast. Depending on part geometry, contour cast parts ranging from 1 to 100 lb can be produced at present.

2. *Tolerances*—As-cast tolerances at present are similar to those of sand cast steel. They average about ±0.030 in. for parts up to 1 in.; 0.004 in. per in. for parts over 1 in.

3. *Finish*—Any finish producible in the mold can be reproduced. Finishes ranging from highly polished to crude sandblast have been produced.

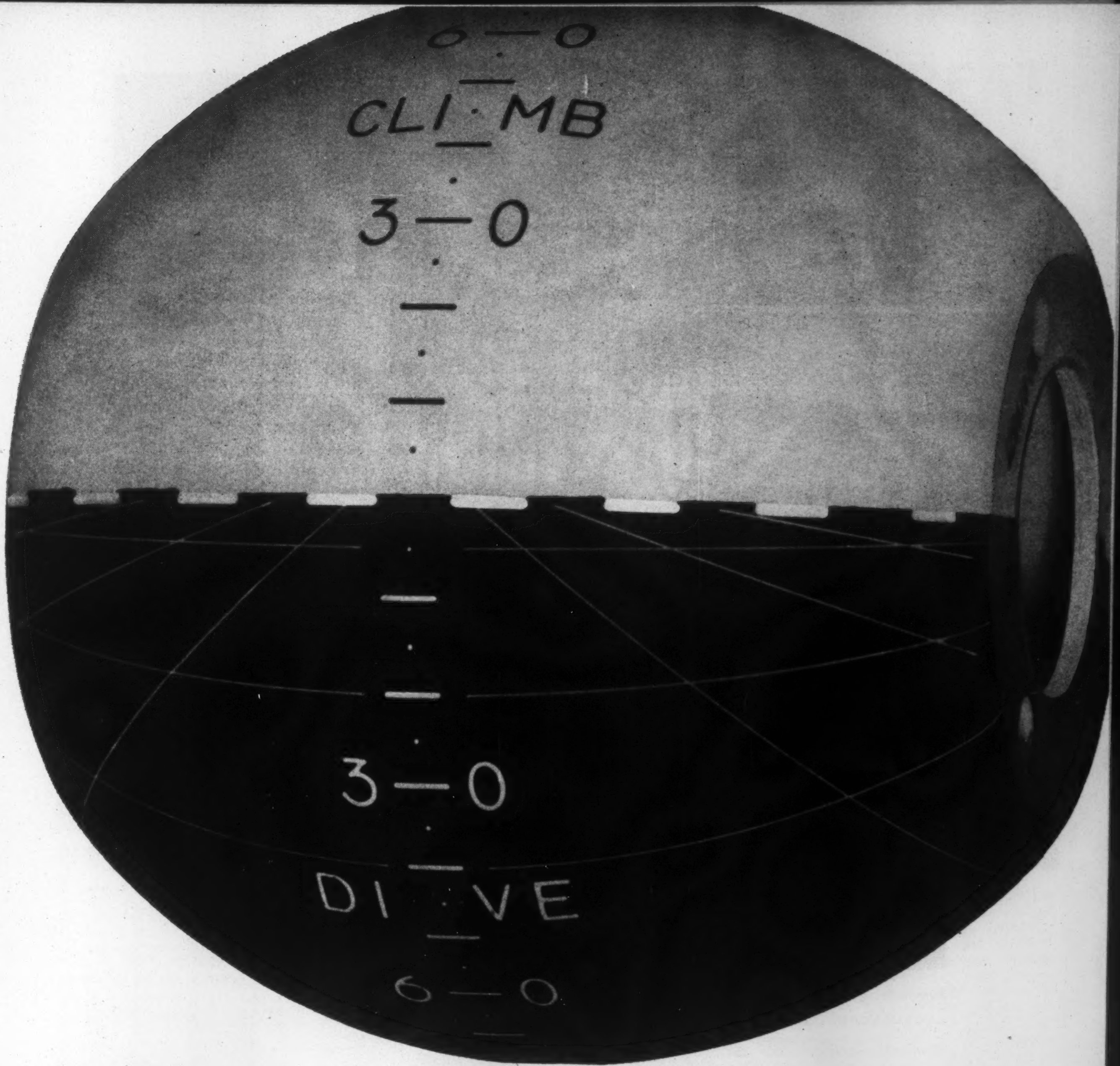
4. *Duplication and detail*—Fine detail such as limited undercuts and reverse steps can be reproduced accurately. The casting process permits rapid duplication of existing parts or models. Initial parts can be delivered in a matter of days when existing models or parts can be used as patterns.

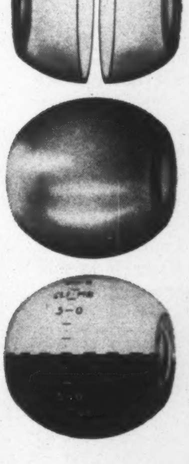
Typical parts visualized

According to Polymer Corp., MC nylon may provide benefits in any industry now using large metal or plastics parts where important requirements include impact strength, wear resistance, light weight, corrosion resistance, low friction, sound damping and nongalling.

Parts for which it is suitable include large bushings and bearings, equipment for handling abrasive materials, gears, valve seats, covers for rolls, slipper blocks, drilling chucks, large hydraulic back-up rings, and cams on automatic screw machines.

Test pieces of MC nylon inserted into foundry core boxes have provided ten times the wear resistance of hardened steel inserts, according to Polymer Corp. The company anticipates entire





Lexan resin provides dimensional stability in close-tolerance parts

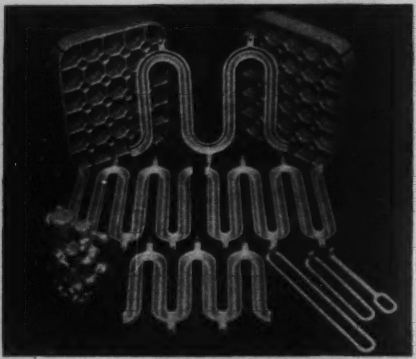
Maximum change allowable in the overall dimensions of this five-inch attitude indicator component is only 5 mils over a temperature range of –65° to 300°F! Moreover, the aircraft instrument part must maintain these tolerances under conditions of high humidity. To meet these severe requirements for dimensional stability, Lear, Inc. selected LEXAN polycarbonate resin.

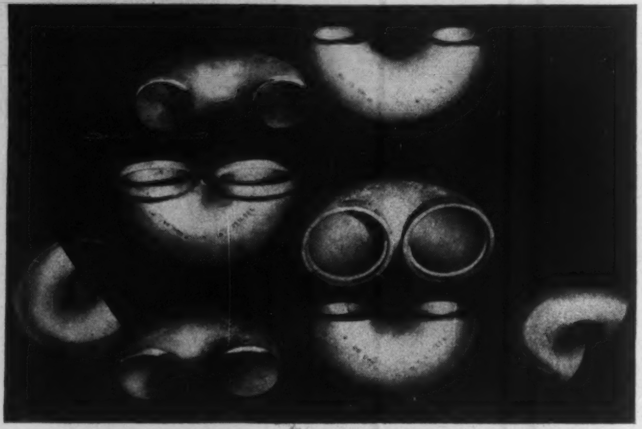
In addition to high performance, LEXAN offers easy and versatile fabrication. Thermoplastic, it is injection molded in half spheres which are joined by solvent cementing. After lathe turning to insure complete accuracy, the spheres are painted three different colors. Maximum visibility is obtained by lighting from the inside. With their high temperature resistance and high impact strength, these polycarbonate spheres are both rugged and precise design elements. They are fabricated for the Instrument Division of Lear, Inc. by Monroe Industries — both of Grand Rapids, Mich.

This component is an example of what high-performance LEXAN polycarbonate resin can do for your designs. The price of the resin has gone down, too, as production has gone up. Can *you* afford to overlook the major advantages of this new, major design material? Send for design literature.

LEXAN®
Polycarbonate Resin
GENERAL ELECTRIC
Chemical Materials Dept., Section M-91 Pittsfield, Mass.

For more information, turn to Reader Service card, circle No. 365





DURASHEL

SHELL MOLDED CASTINGS

Permitting Desirable Departures from Conventional Castings:

- *much more intricate design.*
- *thinner wall sections.*

Coupled with these are the close adherence to design dimensions, superior finish and faster production.

If you are looking for quantity deliveries on castings ranging in weight from an ounce or two to several pounds, our shell molding department is at your service. It is backed by nearly forty years broad experience in the high alloy casting field, which covers static and centrifugal castings as well as shell molded.

Send for Bulletin G-159.

ALLOY CASTING INSTITUTE ACI MEMBER

The DURALOY Company
OFFICE AND PLANT: Scottdale, Pa.
EASTERN OFFICE: 12 East 41st Street, New York 17, N. Y.
CHICAGO OFFICE: 332 South Michigan Avenue, Chicago, Illinois
DETROIT OFFICE: 1025 Maple Road, Troy, Michigan
HOUSTON OFFICE: 4101 San Jacinto, Houston 4, Texas

For more information, turn to Reader Service card, circle No. 384

core boxes and draw plates fabricated of the material. Similar applications should be found in components of mining equipment, crushing and grinding equipment, and chutes and slides for handling cement, gravel and coal.

Other potential applications include suction box covers in the paper industry, tooling for metal drawing and roll forming, and railroad equipment such as thrust bearings, journal stops, and truck support disks.

Mill shapes available

Both custom castings and mill shapes are available. At present, custom complex shapes ranging from 1 to 100 lb in size are being made on a limited basis.

Mill shapes available include:

1. *Tubular bar:* O.d.'s from 2 to 15 in.; i.d.'s from 1 to 4¼ in. Bars up to 30 in. dia and up to 10 ft in length can be supplied on special order.

2. *Plate:* In thicknesses of ¼ to 4 in., standard sizes are 24 x 48 in. Plate up to 6 in. thick and 4 × 10 ft in size are available on order.

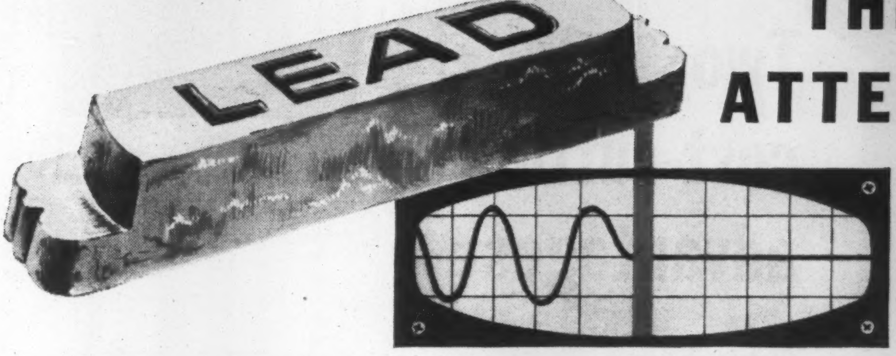
3. *Rod:* Diameters from 3 to 8 in.; lengths from 6 to 24 in. Rods up to 24 in. dia are available in 8-in. lengths on order.

Steel Spring Wire Has High Strength

A new stainless steel spring wire is recommended for highly stressed applications as in jet engines, food and beverage equipment, and chemical process machinery. The producer says tests on 0.075-in. wire show it has a tensile strength that is up to 100,000 psi higher than that of commonly used music spring wire.

The new steel wire, designated NS-355, is available from National-Standard Co., Niles, Mich. It is sold in diameters ranging from 0.003 to 0.195 in.

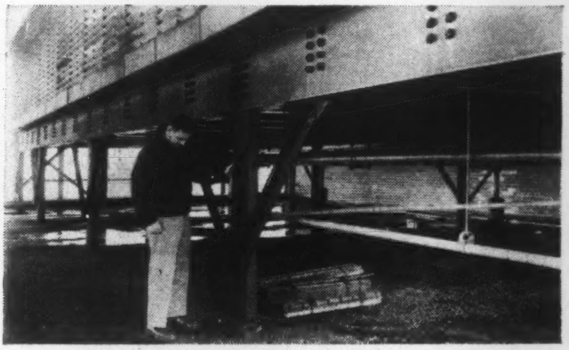
Guaranteed minimum tensile strength of 0.195-in. wire is 290,000 psi, compared to 245,000 psi for



THE GREAT ATTENUATOR*

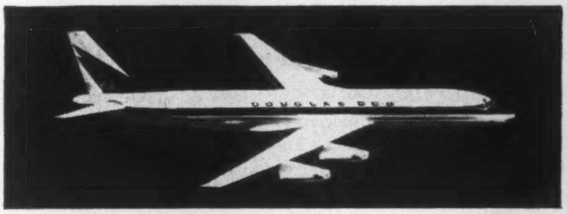
*Attenuation — Diminution of force, intensity, etc.

No other material equals LEAD'S combination of effective attenuation, low cost and compactness



IN DAMPING VIBRATION

Lead anti-vibration pads have proved an effective barrier to vibration created by railroad trains, printing presses, commerical laundry equipment and similar machinery. In the installation shown here, the roof-top cooling tower for an air conditioning system is mounted on lead pads which isolate the vibration from the building.

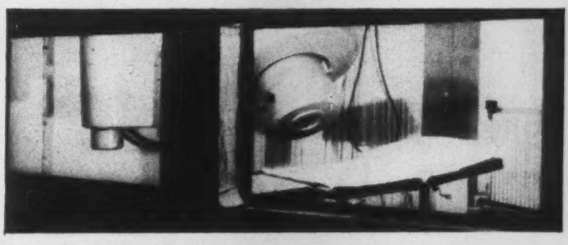


IN QUIETING NOISE

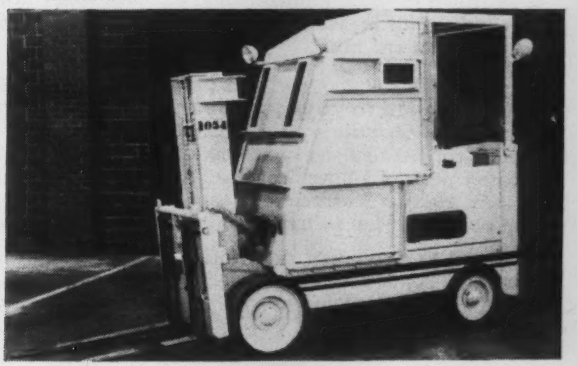
Because it is a dense, limp material, lead is an excellent sound attenuator and isolator. In powder form it is impregnated into the vinyl covering of a new acoustical fabric used to cut down engine roar in both conventional and jet airliners. This leaded fabric is also being used for sound attenuation in other applications such as electric typewriters.

IN RADIATION SHIELDING

X-RAY — Lead has long been the standard material for protection against harmful exposure to X-rays. It is used in the floors, walls, ceilings, doors and windows of X-ray rooms, in the protective clothing for technicians and in the beam-shaping apparatus of the machine itself.



GAMMA RAYS — Attenuation of gamma radiation is directly proportional to the density of the shield. Since lead is the densest of all commonly available materials, it gives the best protection per unit of thickness at lowest cost. It is widely used in nuclear reactors, radioactive waste containers and nuclear laboratories. Photo shows a lead-shielded fork lift truck with leaded glass viewing ports, used for transporting radioactive materials.



ST. JOE

PB-165

ST. JOSEPH LEAD COMPANY
250 Park Avenue
New York 17, New York
THE LARGEST PRODUCER OF LEAD IN THE UNITED STATES

For more information, turn to Reader Service card, circle No. 420

Two cost-cutting advantages in modern Hackney Air Receivers

✓ **Seven standard capacities**—Costs come down when you specify Hackney air receivers. In the Hackney line, you can choose standard capacities that will best suit many of your needs from stock.

Modern Hackney air receivers depart from conventional design to give you stronger, lighter construction. Made with two smooth seamless shells, cold drawn to exact diameters and uniform wall thicknesses, they meet the demands of all pressure vessel codes. *One* circumferential weld minimizes seam area of the tank.

✓ **Supplied to your schedule**—Hackney 2-piece air receivers can be supplied in *quantities* on a schedule geared to *your* assembly operations. Openings, fittings, legs and saddles for compressor and motor can be located per your specifications. And should you need special capacities or construction features, our experience as well as our complete facilities can point the way to more economical production costs.

Capacities: *Standard* horizontal—30, 60, 80 and 120 gallons. *Standard* vertical—30, 60 and 80 gallons.

For complete specifications and details, send for our new air receiver bulletin, No. AR-1.

Pressed Steel Tank Company
Manufacturer of Hackney Products Since 1902
1442 South 66th Street, Milwaukee 14, Wisconsin
Branch offices in principal cities

CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

For more information, turn to Reader Service card, circle No. 400

PROPERTIES OF NS-355 WIRE

Density, lb/cu in.	0.282
Modulus of Elasticity, psi	
80 F	29.3×10^6
800 F	24.6×10^6
Electrical Resistivity, ohm-cm	
80 F	75.7
1400 F	109.8

COMPOSITION OF NS-355 WIRE (%)

Chromium	15.65
Nickel	4.38
Molybdenum	2.68
Manganese	1.00
Carbon	0.14
Phosphorus	0.03
Sulfur	0.01
Silicon	0.32
Copper	0.12
Nitrogen	0.12

music wire of the same size; 0.004-in. wire is 500,000 psi, compared to 439,000 psi for music wire.

Low spring index

Tests using 0.125 and 0.075-in. wire on automatic coiling machines show the material can achieve a spring index as low as 3 without breaking. Spring index is the ratio of mean spring diameter to mean spring wire diameter.

The wire is slightly attracted to a magnet when annealed and is readily attracted when spring tempered.

KEY NO. 610

Silicone Fluids Are Solvent Resistant

A new class of silicone fluids has been developed by the Silicone Products Dept. of General Electric Co., Waterford, N. Y. Nitrile groups in the fluids are said to give them good solvent resistance and high dielectric constant.

Four grades available

Four experimental fluids are available at present. The products are numbered XF-1105, XF-1112, XF-1125 and XF-1150: the last two digits indicate cyanoethyl content. Introductory prices range from $11 to $16 per lb.

The fluids are expected to be used for non-aqueous antifoams, base stocks for solvent resistant greases and coatings, antistatic agents, and

NEW FROM DU PONT...
a thermoplastic "Teflon" film that's easy to fabricate

TEFLON® FEP FILM

LAMINATE IT!
BOND IT!
FORM IT!

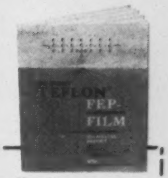
New "TEFLON"* FEP-fluorocarbon film has nearly *all* the unique advantages of "TEFLON" TFE with one big plus. It's a true thermoplastic that can be easily formed and sealed. One type of this new film can be applied *with* adhesives, another can be laminated and heat-bonded *without* them.

Here are just some of the advantages of "TEFLON" you get in this new film • Unique antistick and low-friction properties • Chemically inert to practically all known chemicals • Electricals are high (up to 4,000 volts/mil dielectric strength) and *stay* high • Performance stays virtually constant from -250°C. to over 200°C.

"TEFLON" FEP film opens the door to whole new areas of design and product improvement. Mail coupon and start investigating "TEFLON" FEP film for yourself. (Briefly describe the end use you have in mind.)

**Du Pont trademark*

DU PONT
REG. U. S. PAT. OFF.
BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY



E. I. du Pont de Nemours & Co. (Inc.)
Film Department 9531-N (T)
Wilmington 98, Delaware

Name________________________

Company Name____________________

Address________________________

____

Job Function_____________________

Proposed End Use_________________

For more information, turn to Reader Service card, circle No. 481

Time-tested Standard of the Resistor Industry!

EVANOHM
W. B. DRIVER CO.
EVANOHM
NEWARK, N.J. NEW JERSEY

SPECIFICATIONS

Nominal composition
75% Nickel
20% Chromium
2.5% Aluminum
2.5% Copper

Specific resistance 20°C
800 ohms/cmf
134 microhm cm

Coefficient of linear expansion 20° to 100°C
.000014/°C

Specific gravity
8.10 gm/cc

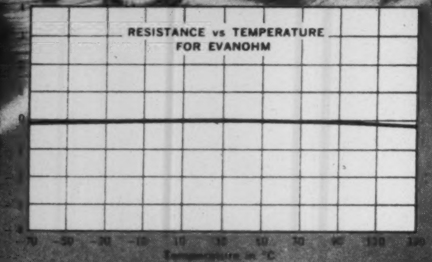
Pounds per cubic inch
.293

Magnetic attraction
None

Average tensile strength
180,000 psi

Thermal conductivity
0.152 W/cm/°C

Mean thermal EMF vs copper 0°C to 100°C
1 μv/°C



Specify EVANOHM for exceptional stability over wide temperature ranges. This WBD precision resistance alloy provides high specific resistance, low temperature coefficient and low thermal EMF to copper. It is especially recommended for high reliability applications . . . resistors, precision instruments, missiles and critical equipment. Available in bare wire, enameled or insulated.

FINE WIRE ALLOYS IN A FULL RANGE OF RESISTIVITIES

ALLOY	Nominal Composition	Resistivity (ohms/cmf)	T.C. of Resistance (ohms/ohm/°C, 20-100°C)	Specific Gravity gms/cc
Evanohm®	75 Ni-20 Cr-2.5 Al-2.5 Cu	800	±.000005† (−65° to 125° C.)	8.10
Tophet A®	80 Ni-20 Cr	650	.000085	8.412
Tophet® C	61 Ni-15 Cr-bal. Fe	675	.00013	8.247
Cupron® (Constantan)	55-Cu-45 Ni	294	±.000020	8.90
Balco®	70 Ni-30 Fe	120	.0045	8.46
Ballast® (Pure Nickel)	99.7 Ni	48	.0060	8.90
30,60,90,180 Alloys	Cu-Ni	30-180	.00130 -.00018	8.90

† .002" and finer

Call or write for EVANOHM brochure to—

WILBUR B. DRIVER COMPANY
NEWARK 4, NEW JERSEY — Telephone: HUmboldt 2-5550

In Canada: Canadian Wilbur B. Driver Co., Ltd., 50 Ronson Drive, Rexdale (Toronto)

PRECISION RESISTANCE, ELECTRONIC AND MECHANICAL ALLOYS FOR ALL REQUIREMENTS

For more information, turn to Reader Service card, circle No. 369

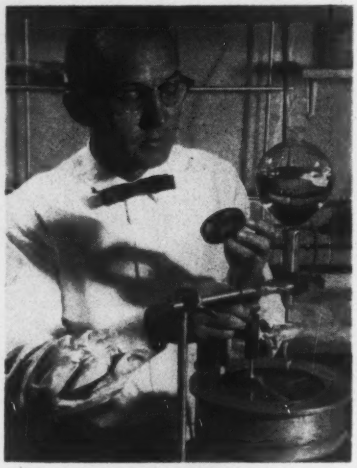
plasticizers and additives for various plastics.

The new fluids are insoluble in nonpolar solvents such as aliphatic and aromatic hydrocarbons, and soluble in certain polar solvents such as alcohols, ketones and ethers. Other properties are as follows:

Hydrolytic stability: The fluids do not hydrolyze or decompose after 90 hr in boiling distilled water.

Thermal stability: The fluids do not have the thermal stability of other methyl and phenyl silicone fluids at high temperatures, but weight loss tests indicate possible usefulness for long periods at temperatures up to 300 F.

Dielectric constant: The dielectric



Polishing germanium — A new electrochemical technique for rapid, scratch-free polishing of germanium and silicon wafers for transistors has been announced by Bell Telephone Laboratories, 463 West St., New York 14. Semiconductor slices are mounted on a nonconducting disk. After electrical contact is made to the slices, they are placed on a polishing wheel over which an electrolyte flows. The slices are then electroetched and polished to a smooth surface. When the polishing wheel rotates, a film of electrolyte separates and automatically maintains the semiconductor at a relatively constant distance from the wheel. **KEY NO. 612**

New strippable plastic film for protection of stainless steel surfaces

Protects your product quality during handling and fabrication while offering these eight distinct advantages:

- 20% cheaper than adhesive paper
- Will not bleed or discolor surface finish
- Greater resistance to scratching and abrasion
- Extremely flexible—stretches well during forming, drawing and embossing
- Can be sheared, slit, blanked or nibbled without lifting film at cut edge
- Will not embrittle during storage—retains elasticity
- Reduces wear on polished dies—eliminates lubricants in some instances
- Strips off easily—leaves no residue; final cleaning unnecessary

You get greater protection *plus* economy with the new in-fab plastic coating now being applied to MicroRold® stainless steel sheet, cut strip, and coiled sheet and strip. The semi-transparent protective film is 20% lower in cost than regular adhesive paper and offers more versatility in fabrication. The protective film is applied at our mill on customer order only, and is available on stainless steel in gages from .018″ to .050″ in widths up to 42″. It is guaranteed to strip off in one piece by loosening with fingernail at any corner.

Strippable plastic protection is intended as a safeguard only during ordinary handling, storage and fabrication—*not* as a barrier for weather, water damage, undue abrasion, impact or foreign substance. Once removed it will not adhere again.

Want more information or a test sample? Write to Product Development Dept., Washington Steel Corporation, 9-F Woodland Ave., Washington, Pa.

WASHINGTON STEEL CORPORATION

Woodland Avenue
Washington, Pa.

For more information, turn to Reader Service card, circle No. 320

corrosion resistant **DURACOR** replaces costly metal fabrications

in the
METALWORKING
industry

Ceilcote engineers complete ventilating systems, gas scrubbing towers, hoods, tank covers, ducts, recovery tanks and other customized fabrications.

in the
TEXTILE
industry

Complex rayon spin machines, feed pipes, filters, screens, tanks and similar equipment are fabricated from Duracor.

in the
PETROLEUM
industry

Acid storage tanks, tank trailers, exhaust systems, pressure pipes and other Duracor products are rendering outstanding service.

in the
CHEMICAL
industry

Duracor is used extensively for special processing equipment, processing tanks, laboratory sinks, brine tanks, acid storage tanks, covers and ventilating systems.

PHYSICAL PROPERTIES

Tensile Strength p.s.i.: 11,000-15,000
Flexural Strength p.s.i.: 20,000-30,000
Tensile Modulus of Elasticity p.s.i.: 1.2—1.4 x 10^6
Flexural Modulus of Elasticity p.s.i.: 0.78—1.6 x 10^6
Impact Izod, Notched ft.-lbs./in.: 30—40
Specific Gravity: 1.4
Coefficient of Linear Expansion: 9.5 x 10^{-6} in./in./°F.
Standard Color: Light Green/Gray
Maximum Temperature (Exposure): To 500°F.

Save up to 40% over costly metal structures with Duracor processing equipment and ventilating systems! A product of Ceilcote's 33 years of corrosionproofing experience, Duracor combines extreme chemical resistance and high strength with light weight, heat and flame resistance. WRITE TODAY FOR VISUAL STANDARDS AND INDUSTRY SPECIFICATIONS!

DURACOR CEILCOTE

THE CEILCOTE COMPANY, inc.
4899 Ridge Road • Cleveland 22, Ohio

8595-CC

For more information, turn to Reader Service card, circle No. 393

constant of the new fluids ranges from 3 to 20 at 60 cps, compared to 2.5-3.0 for standard silicone fluids.

Electrical conductivity: According to GE, nitrile silicone fluids can be formulated with a volume resistivity of 10^9 ohm-cm, compared to 10^{13}-10^{14} for conventional silicone fluids.

Surface tension: The surface tension of the new fluids ranges from 23 to 26 dynes per cm, compared to 21 to 23 for dimethyl silicone fluids.

Toxicity: Preliminary toxicological tests indicate the fluids are relatively nontoxic. **KEY NO. 611**

Noted briefly in our June issue.

Gold Electroplates Are Hard, Ductile, Pure

A new acid-type electroplating solution is said to produce high purity (99.99+%), 24-karat gold deposits to any desired practical thickness.

Called Temperex HD, the formulation is available from Sel-Rex Corp., Nutley 10, N. J. It is especially suited for gold plating electronic devices such as transistors.

Chief advantages of deposits from the formulation are: high hardness (75 Knoop), good ductility, good machinability, and good solderability and weldability.

The plating solution is adaptable to both still and barrel plating operations. **KEY NO. 613**

Noted briefly in our July issue.

Light Ablation Plastic for Rocket Applications

A new ablation plastic for missile and rocket applications such as motor liners and exhaust cones has been introduced by Taylor Fibre Co., Norristown, Pa.

The high pressure reinforced plastic, designated Tayloron 5000, consists of alternate layers of asbestos and nylon impregnated with a proprietary, high temperature phenolic resin. A big advantage of the material is that it is 25% lighter in weight than similar materials now used for rocket and missile parts.

The plastic is also said to have

Nickel-Chrome Plating shines through the years of wear she'll give this bicycle

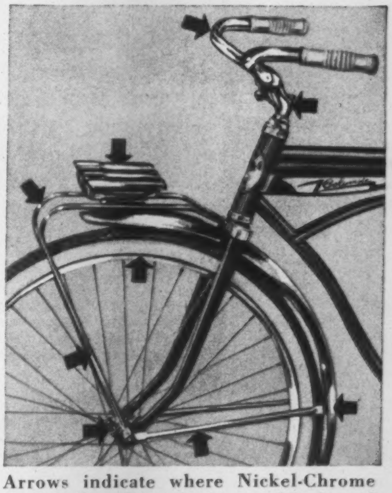
Nickel-Chrome Plating is more than a match for the hard wear that means bicycling fun for youngsters. It's beautiful, it's durable—*and stays that way*—despite rain, dust, bumps and scratches.

Rugged resistance to corrosion and lasting protection for the basis metal are why the manufacturers of this beautiful bicycle specify Nickel-Chrome Plating. It's put to work where wear is at its worst—on cranks, sprockets, wheel rims, fenders, handlebars and wire and tubular luggage carriers.

Nickel-Chrome Plating works so well with so many basis metals. It gives designers true flexibility in selecting basis materials for top performance, simplified fabrication, and practical production cost. And it gives metal finishers a coating system that protects the product for years of rugged wear.

Plan to use Nickel-Chrome Plating. Automotive trim...large and small appliances...hand plumbing fixtures...almost any product can have a durable, attractive finish—no matter what basis metal or fabricating method is used. For more information on decorative plating, write for your copy of "The Contribution of Nickel and Chromium to the Durability of Decorative Plating."

The International Nickel Company, Inc.
67 Wall Street INCO New York 5, N. Y.

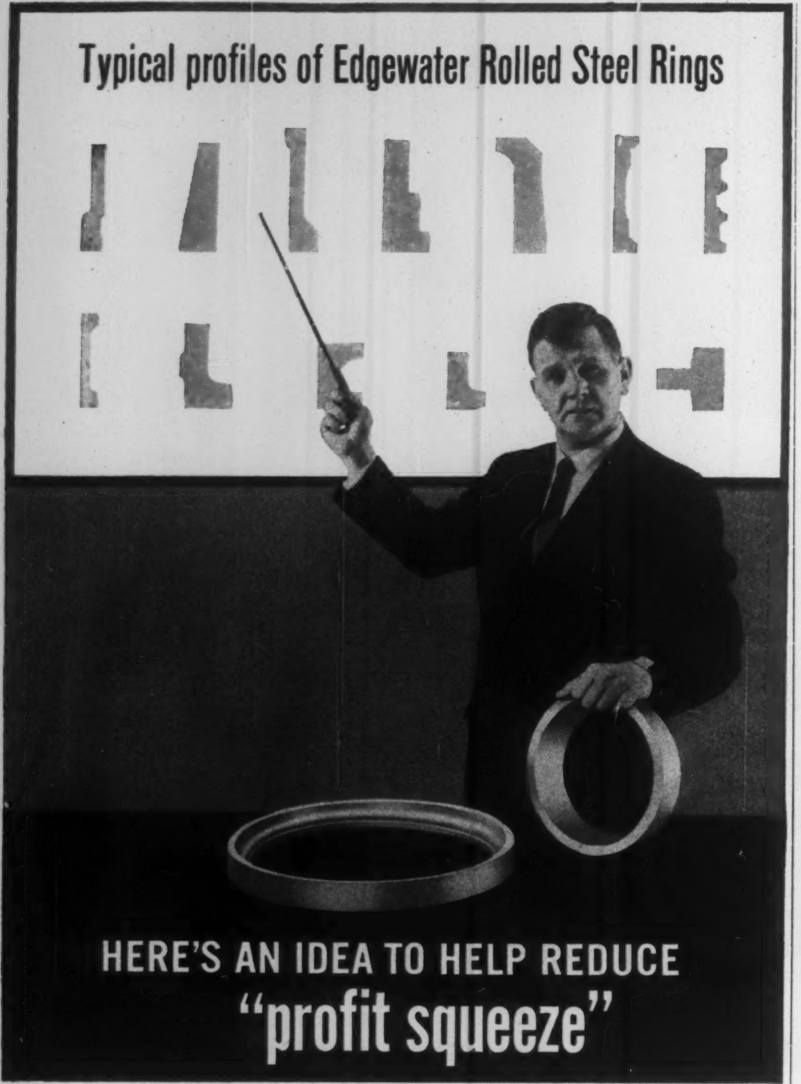


Arrows indicate where Nickel-Chrome Plating is used for shining good looks and rugged service.

Inco Nickel

Nickel makes plating perform better longer

For more information, turn to Reader Service card, circle No. 440


Typical profiles of Edgewater Rolled Steel Rings
HERE'S AN IDEA TO HELP REDUCE
"profit squeeze"

Buy rings that are formed so close to finished shape and dimensions that very little machining will be needed. The result—less labor, less scrap loss, lower overall cost.

Edgewater rings are forged from solid blocks of steel, and rolled by a powerful ring-rolling mill to required cross-section shapes (see typical profiles above). Close tolerances minimize finishing operations.

Edgewater rolled steel rings are of uniform quality, strong and tough. Diameters: from 5 to 145 inches. Send drawings for recommendations and prices.

INTERESTING description of the ring-rolling process is given in this brochure, **Edgewater Rolled Steel Rings.** We will be glad to send you a copy.

EDGEWATER STEEL COMPANY
P. O. Box 478 Dept. MDE, Pittsburgh 30, Pa.

For more information, turn to Reader Service card, circle No. 439

PROPERTIES OF TAYLORON 5000

Sp Gr	1.36-1.40
Water Abs, %	0.25-0.30
Flex Str, psi	
Lengthwise	17,000
Crosswise	14,000
Ten Str, psi	
Lengthwise	14,000
Crosswise	9,000
Ten Mod, psi	
Lengthwise	1.37×10^6
Crosswise	1.05×10^6
Compr Str, psi	30,000
Rockwell Hardness	M100
Ther Cond, Btu/hr/sq ft/°F/in.	
150 F	0.71
200 F	0.75
250 F	0.77
Sp Ht, Btu/lb/°F	0.29

good ablation and heat resistance. Tests show that a ¼-in. thick specimen of the material has a burn-through time of 5 to 6 min when exposed to a 5000 F flame; it takes 160 to 170 sec for the cold face of the specimen to rise to a temperature of 400 F.

The new material is supplied as rods, tubes, sheets and plates. A prepreg form, called Tayloron 5000B, is also available for molding and lay-up laminating of large and small shapes. **KEY NO. 614**

Colloidal Alumina Strengthens Materials

A new colloidal alumina can be used to improve the properties of a variety of engineering materials, including metals, ceramics, paints and plastics.

Called Baymal, the alumina disperses and swells in water to form a stable colloid. It is currently available in developmental quantities from E. I. du Pont de Nemours & Co., Inc., Wilmington, Del. Introductory price is $3.50 per lb.

Six important properties

The new material has six important properties: 1) it is water dispersible; 2) it consists of fibrillar particles that result in film formation; 3) it has very small particle size and therefore high surface reactivity; 4) it has a positive ionic charge in aqueous dispersions; 5) it has both a hydrophilic and organo-

METHANE PIONEER

How wood engineering helps this ship do the work of a fleet

THIS SHIP — the METHANE PIONEER — is the only one in the world that has ever transported a cargo of liquid methane across the ocean — and she's done it regularly.

It would take 600 ships like this one to transport a load of liquid methane in its natural, gaseous form! By bringing its temperature down to –258°F. at atmospheric pressure, the methane is liquefied to a small fraction of its original volume.

How does *wood engineering* enter into all this? Because wood is a good insulator whose strength increases as temperature decreases. Its properties make possible an insulating system (for the storage tanks) that is liquid-tight, load-bearing, and retains its integrity despite extreme cold and the rack of the ship. Gamble Brothers wood engineers assisted their client, Constock (now Conch) International Methane, Ltd., in the design—then fabricated and installed a foot-thick, balsa-wood-panel insulating system that has met all requirements.

Problems like this are "all in a day's work" to the wood engineers at Gamble Brothers—a unique organization designing and building a wider variety of wood products than any other U. S. woodworking company. Today they're working in three principal areas: (1) improvement of present wood products (2) development of new wood products (3) product development in combinations of wood and other materials.

Why not present *your* design problem to Gamble Brothers? WOOD may be the answer!

FREE booklet illustrates GAMBLE services

This 28-page booklet describes Gamble facilities and services in detail. Includes many photographs of unusual products designed, tested and perfected by Gamble Brothers. Write for your copy today! Gamble Brothers, Inc., 4627 Allmond Ave., Louisville, Ky.

Solving Problems in Wood

If the problem involves wood, Gamble can help!

GAMBLE BROTHERS GUARANTEED BOND

GAMBLE BROTHERS, INC.

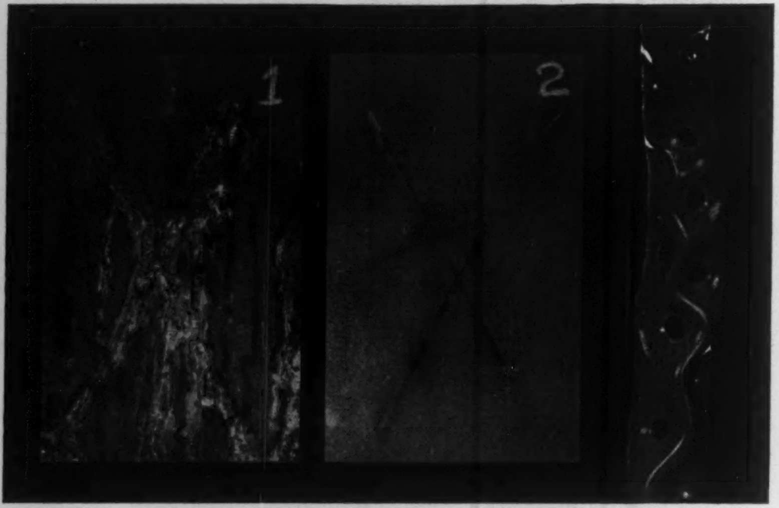
4627 Allmond Avenue, Louisville, Kentucky

For more information, turn to Reader Service card, circle No. 367

For economical under-paint protection.

ask Oakite

OVER 50 YEARS CLEANING EXPERIENCE • OVER 250 SERVICE MEN • OVER 160 MATERIALS



These two panels were identically painted, scored with an "X", and exposed to salt spray test for 480 hours. The difference: the one on the right was first treated with an Oakite CRYSCOAT iron phosphate conversion coating.

This painted tubing was CrysCoated. Repeated punching did not break paint grip despite severe abuse and deformation.

Oakite CRYSCOAT® iron phosphate coatings cut the cost of corrosion-protection

You get proper protection *plus* economy with CrysCoat iron phosphate coatings.

First of all, they lock paint to steel, giving a superior paint grip under bending stresses. Bend tests show less chipping and flaking of paint. And note how paint held tight even at punched holes in the sample above.

Secondly, they keep corrosion from spreading at every scratch, as the panels above show so graphically.

But most important, they save money. Because CRYSCOAT iron phosphate processes *clean* as they phosphate. Because you need only a three-stage washer. Because *no* acid-proof equipment is required. You save both on equipment and production time. In addition, the smoother iron phosphate coatings soak up less paint than coarser phosphate coatings . . . giving you a sleek finish with one less coat.

It will pay you to *ask Oakite* about phosphating. You'll find the right one for *your* requirements in the complete CrysCoat line which includes both zinc and iron phosphate processes, for spray or tank, for room or elevated temperature operations. Meanwhile, write for Bulletin F-9475. Oakite Products, Inc., 26H Rector Street, New York 6, N. Y.

it PAYS to ask Oakite

OAKITE
SCIENCE
over 50 Est. 1909 years' leadership in industrial cleaning

For more information, turn to Reader Service card, circle No. 326

philic nature; and 6) it is low in toxicity.

Potential uses

Inorganic fibers: High surface area, positive charge and film forming properties are said to make the alumina an effective binder for use in such inorganic fibers as glass, asbestos, rock wool and aluminosilicates.

Coatings: Coherent, clear-to-translucent coatings of the colloidal alumina can be applied to many types of surfaces for protective and decorative effects. According to Du Pont, the coatings are microporous, readily wetted and slowly permeable to water and polar organic solvents. Thin films of the material are said to contribute both antisoil and antistatic properties to materials coated.

Ceramics: The alumina can be used to increase plasticity of ceramic slips for improved extrudability. It can also be used as a refractory coating to improve heat and abrasion resistance of ceramic surfaces.

When used alone, Baymal can be cold pressed to form alumina bodies with high strength in the unfired state. These bodies can be fired to density at temperatures somewhat lower than for large-particle, commercial alumina powders. The fired material does not crack or craze and does not change its relative dimensions, according to Du Pont.

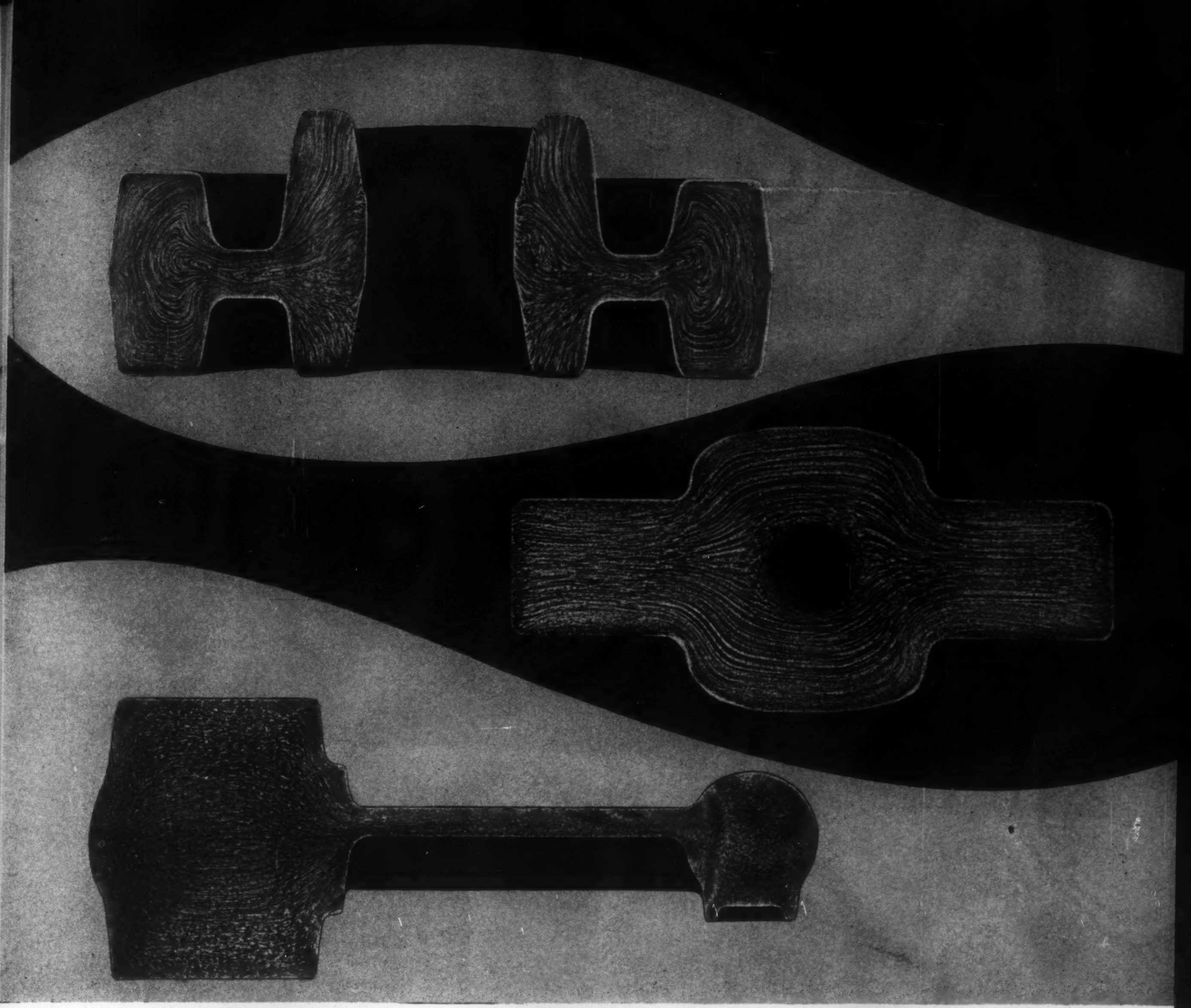
Noted briefly in our June issue.

KEY NO. 615

Permanent Magnet Has Improved Properties

A new permanent magnet material, called Alnico VIII, is said to have over twice as much resistance to demagnetization as Alnico V. Coercive force and maximum energy product of the material are said to be substantially higher than those for Alnico VI and VII. Temperature stability of the new material is excellent, according to the developer.

The material, now available from Crucible Steel Co. of America, P. O. Box 88, Pittsburgh 30, is the newest addition to a group of dispersion hardened alloys containing alumi-



Only FORGED *parts have flow lines like these*

When quality steel forgings are cut in half, polished, etched, and dyed, you can see one reason for their great strength. The grain structure shows how the forging process has "worked" added strength into the steel. Note how the grain follows the contour of the forgings, placing the greatest strength where it is most needed.

FORGED STEEL IS SOUND STEEL

Forged steel has strength without undue bulk. It's economical because it saves many costly machining and fabricating operations. Forging improves the steel's mechanical properties, adds to its service life.

SOUND STEEL "MAKES" THE FORGING

No one knows better than the forger that *the quality of the steel is a forging's most important ingredient.* That's why so many forgers use Bethlehem steels—carbon and alloy grades they can always rely on to meet their requirements. You'll find you can rely on them, too.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

Export Sales: Bethlehem Steel Export Corporation

Steel *for Strength*
. . . Economy
. . . Versatility

BETHLEHEM STEEL

BETHLEHEM STEEL

For more information, turn to Reader Service card, circle No. 407

IMPERVIOUS ALUMINA OR MULLITE...

CERAMIC INSULATING TUBING

FOR TEMPERATURES TO 3600° F!

Sizes .020 and larger! Lengths to 60", depending on diameter and body specification! Rods also available!

Write for information today!

McDANEL Industrial CERAMICS Since 1919

McDANEL
REFRACTORY PORCELAIN COMPANY
BEAVER FALLS · PENNSYLVANIA

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COMPOSITION OF ALNICO VIII (%)

Aluminum	7
Nickel	15
Cobalt	35
Iron	34
Copper	4
Titanium	5

PROPERTIES OF ALNICO VIII

Density, lb/cu in.	0.265
Elec Res, ohm-cm	50×10^{-6}
Rockwell Hardness	C58
Residual Induction (B_r), gauss	8700
Coercive Force (H_c), oersteds	1450
Max Energy Product (BH)	4.5×10^6

num, nickel, cobalt, iron, copper and titanium. It is expected to be used in motors, generators, speakers and meters.

The magnet material is cast to shape in sand or shell molds and further formed by abrasive cutting and grinding. It requires a magnetic heat treatment to develop strong directional magnetic properties. **KEY NO. 616**

Phenolic Extrusions Are Strong, Low Cost

Limited commercial production of phenolic and other thermosetting plastics extrusions has been announced by York Industrial Plastics, Inc., York, Pa.

The producer says extruded phenolic parts have a very fine surface finish with a higher gloss than parts produced by other methods. Physical and electrical properties are about the same as those of parts made by conventional methods.

The extrusion technique for thermosets has been in use in Europe for some time and is now being developed as a production tool in this country. The process is said to offer a means of continuously producing not only rod and tubing, but also other shapes of highly complicated cross section, in any length desired.

Compete with laminates

The phenolic extrusions are expected to compete with paper-phenolic laminates and aluminum extrusions in a number of applications. The phenolic extrusions have higher compressive strength and better elec-

An example of Avisco Rayons in Industry

Why the medical profession is interested in new Medical grades of Avisco® rayon

Wherever they have been demonstrated, medical grades of Avisco rayon have stirred the interest of manufacturers of medical and hygienic supplies. The reasons are clear.

1. They require no cleaning to remove foreign particles.
2. Products have less lint because the fiber length is controlled and uniform.
3. They absorb faster, and more.
4. Products have longer shelf life.
5. They're whiter and softer.
6. They have no static hazard.

(Rayon is the only man-made fiber permitted for operating room use by NFPA Code for Use of Flammable Anesthetics # 56)

Tests made by a leading manufacturer of surgical dressings and bandages dramatically prove that absorbent balls of an Avisco medical grade of rayon not only absorb water faster than the traditional fiber but also maintain a constant rate of absorbency regardless of age. And the same manufacturer states that the rayon balls hold their shape, wet or dry. See for yourself why Avisco medical grade rayons are gaining rapidly in acceptance for medical-hygienic purposes. For information, send in the Quick Reply Coupon below.

QUICK REPLY COUPON 12-4

Industrial Merchandising Division
American Viscose Corporation
350 Fifth Avenue, New York 1, N. Y.

Please contact me about Avisco Rayons for use in the following application:__________

Name__________

Company__________

Address__________

City__________ Zone_____ State__________

AVISCO RAYON

AMERICAN VISCOSE CORPORATION, 350 Fifth Avenue, New York 1, N. Y.

For more information, turn to Reader Service card, circle No. 338

MEEHANITE MEANS BETTER CASTINGS®

MEEHANITE GEARS
serve industry better
through greater economies
in production / in performance
NEW
MEEHANITE
GEAR
BROCHURE

Presents Engineering Data Important To Gear Users

In the design of a gear, the most important single factor is the correct choice of material since it controls the overall dimensions, the degree of accuracy and finish and performance.

This new 16-page brochure presents the essential facts and performance figures on several types of Meehanite metal that are highly recommended and used for a wide range of gear applications. It explains how Meehanite meets important gear requirements and why industry is utilizing more and more Meehanite gears to increase service life and reduce down-time and costs.

Meehanite metal provides a unique combination of properties. Its inherent advantages of high strength with low co-efficient of friction, excellent noise damping capacity, free machinability and resistance to wear and surface fatigue failure contribute greatly to gear accuracy and service reliability.

For your free copy of this informative brochure, write to the Meehanite Metal Corp., New Rochelle, N. Y. Ask for B-53-Meehanite Gears serve industry . . . better.

MEEHANITE METAL

MEEHANITE CASTINGS ARE MADE ONLY BY MEEHANITE FOUNDRIES.

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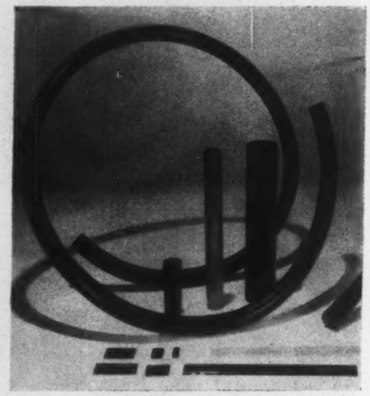


Typical parts *that can be made from phenolic and other resins by a new ram extrusion technique.*

trical properties under wet conditions than paper-phenolic laminates. And cost of the phenolic extrusions is about 50 to 75% less than that of equivalent laminated items.

Compared to aluminum extrusions, the extruded phenolics offer a price advantage in material cost. Built-in color and lower thermal conductivity are said to be additional advantages in such applications as window frames and storm sash.

Ram extrusion technique

The phenolic parts are produced by a ram extrusion technique in which resin is forced through a forming die by a ram. A rising temperature gradient is maintained, and at a predetermined point the material becomes fully plastic. An extended portion of the die provides a curing zone. **KEY NO. 617**

Neoprene Adhesive Has High Peel Strength

A new, general purpose neoprene adhesive is said to give bonds that have high peel strength, remain permanently strong and resilient, and have good water resistance.

The adhesive, called D-239, is available from Armstrong Cork Co., Industrial Div., Lancaster, Pa.

It is designed for bonding supported vinyl fabrics to metal, wood and composition bases; thin-gage metals to wood, asbestos board and

PRODUCT-DESIGN BRIEFS FROM DUREZ

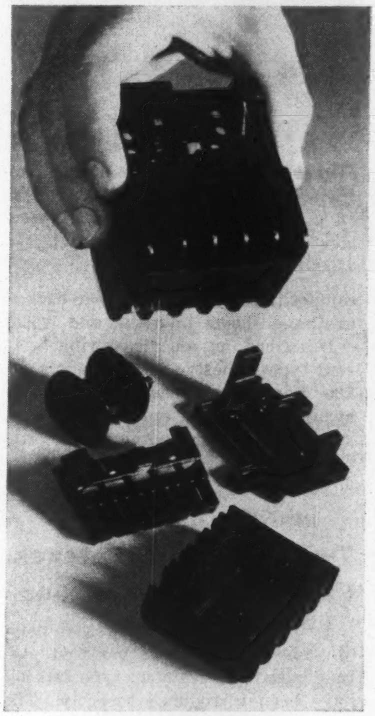
- **Choosing materials for a relay**
- **Building bigger plastic tanks**
- **Designing rust out of a pump**

Space saver

"Build a relay that's small enough to put in a topcoat pocket—and has the power rating of much bigger relays."

This was the challenge Westinghouse engineers faced. They met it with the help of low-cost Durez® phenolic molding compounds.

Five structural members of the new relay are molded from phenolic. All are excellent examples of the fine detail that's achievable with today's phenolics to help you save space.



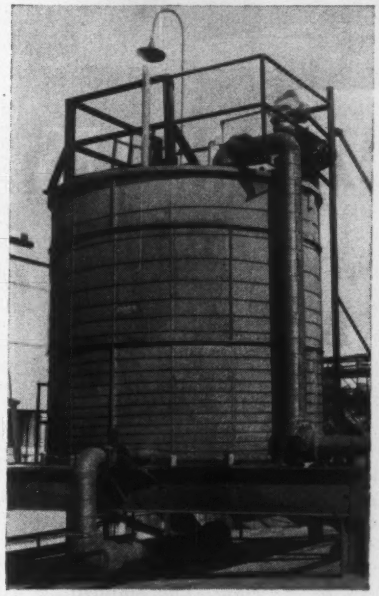
The relay's crossbar (left center), a moving part, requires extra strength in the contact supports. It is transfer molded from a Durez general-purpose compound that provides slightly higher-than-usual impact strength. Edges must be perfect, and very little flash can be tolerated.

All other parts are molded in *Durez 265 Black*, a general-purpose compound chosen mainly for its good moldability.

New twist in tanks

This concept in tank design mates the structural strength of steel with the corrosion resistance and fire retardance of Hetron® polyester-glass laminates.

The result is a very strong, durable tank that can be erected in virtually any size, with a safety factor of 40:1 or better. Besides being corrosion-resistant, the tank is free from galvanic action. Some tanks can be molded translucent, which eliminates the need for gauging. Marketed under the name "Kabe-O-Rap," the tanks are produced by Metal-Cladding, Inc., North Tonawanda, N.Y.



Factory-molded tank segments are made of Hetron resin reinforced with fibrous glass. A stainless-steel cable is wrapped helically around the plastic shell. The cable stabilizes the shell by taking up nearly all stresses transmitted by contained liquids.

This is one of many structural jobs for which designers are choosing Hetron, the inherently self-extinguishing polyester. You can find out all about Hetron and its uses by checking the coupon for a copy of the "Designer's Data File."

Super-tough plastic

This is part of a sump pump. It's the part you normally don't see—because it sits for months at a time in water that's dirty, oily, greasy, soapy, or just plain corrosive.

How, then, can the manufacturer of this pump—Bruner Corporation, Milwaukee—offer a "lifetime guarantee" that this housing won't rust or corrode?

Reason: it's molded of phenolic. No ordinary phenolic, but a high-impact glass-filled material, *Durez 16771*.

This phenolic permits close tolerances, because there's little or no molding shrinkage. The pump housing is rugged enough to support a ⅓-hp motor mounted over the center opening, and a 1¼″ discharge pipe screwed into the hole at upper left. Corrosion tests of the housing indicate it will outwear all common metals, including stainless steel.

We're betting it won't be hard for you to think of places where *you* can use a super-tough, easily molded plastic like this. To help you do so, we've made available a 4-page illustrated bulletin, "Designing High-Impact Phenolic Molded Parts." It gives design rules based on latest experience. Use coupon to request a copy.

For more information on Durez materials mentioned above, check here:

- ☐ "Facts on Phenolics"—pocket guide lists properties of typical Durez molding compounds.
- ☐ "Designer's Data File" describes uses, advantages of Hetron polyester.
- ☐ "Designing High-Impact Phenolic Molded Parts"—4-page illustrated bulletin.

Check, clip, and mail to us with your name, title, company address.

DUREZ PLASTICS DIVISION
1409 WALCK ROAD, NORTH TONAWANDA, N. Y.
HOOKER CHEMICAL CORPORATION

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CHEMICALS
PLASTICS

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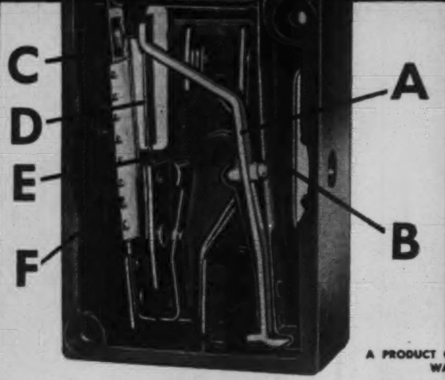
2100
ARK-LES
2300 D23S
MADE IN U.S.A.



Chace
THERMOSTATIC
BIMETAL
ACTUATES ANOTHER
PRECISION PRODUCT . . .

ARK-LES
INFINITE
CONTROL
SWITCH

A PRODUCT OF: ARK-LES INFINITE CONTROLS, INC.
WATERTOWN, MASSACHUSETTS

The ARK-LES Infinite Control Switch is a superb example of the word "infinite". In this application it means an infinite number of heat positions — giving a per cent control of full heat or full wattage regardless of cooking conditions.

To start the cycle, the knob is set at any position except "high". This moves the calibrating arm (A) to the right. The ambient compensating bimetal (B) connected to the arm, acts as a loading spring by transmitting force through the cross link to the main bimetal (C) causing the main bimetal contact to engage the contact on the auxiliary bimetal (D). When the main contacts engage each other, load current flows through the bimetals, causing them to increase in temperature. Main bimetal moves left. Auxiliary bimetal follows this movement, due to the fast-acting narrow bimetal strip (E) on the auxiliary bimetal assembly. Increasing temperature causes the main auxiliary bimetal to move right as the main bimetal is bending left. This effects a clean break. Open, the bimetals cool — the main bimetal much more slowly due to the heat control insulator (F). After a cooling period, both contacts are moving toward each other and the cycle is repeated.

Not one or two, but FOUR pieces of Chace Thermostatic Bimetal actuate this fine ARK-LES product! And this ambient-compensated, thermally-balanced infinite control will act *as specified* for many thousands of cycles. That's dependability. Along with precision Thermostatic Bimetal manufactured to the most exacting specifications, Chace has specialized in utter dependability for more than a third of a century. Manufacturers the world over specify Chace Thermostatic Bimetal with complete confidence.

Send Now For Our New "Information Booklet"!

It contains many well illustrated pages of valuable design data and examples of successful applications of bimetal! More than 40 types of Chace Thermostatic Bimetal are available in coils, strips and completely fabricated elements of your design.

IT BENDS WITH THE HEAT
W. M. CHACE CO.
Thermostatic Bimetal
1615 BEARD AVE., DETROIT 9, MICH.

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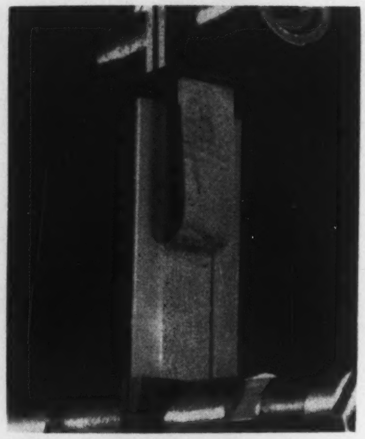

***Flexibility** of new adhesive is demonstrated by this 180-deg peel test of a fabric-backed urethane specimen bonded to a sheet of steel.*

composition bases; and fabric-backed urethane sheets to metal and wood.

Described as an air drying, solvent-type adhesive, Armstrong's D-239 has the consistency of thin syrup and can be applied by brush, spray and roller coater. It is said to have excellent aging properties.

KEY NO. 618

Two Synthetic Latexes Protect Metals, Paper

Two new synthetic latexes—a polyethylene latex and a modified styrene-butadiene resinous type latex—have been introduced recently. The styrene-butadiene latex is designed specifically for use as an air-dry metal primer and the polyethylene latex as a coating on paper.

1. Styrene-butadiene latex

The styrene-butadiene latex, called Pliolite Resin Latex 481-X, is available from the Chemical Div. of Goodyear Tire and Rubber Co., Akron 16, Ohio. It dries clear and nontacky.

The new latex is expected to be used as a primer on automobile bodies, structural steel, farm implements and vending machines. Applied by brush, spray or dip methods, the primer can be top-coated with conventional air-dry or baked enamel finishes.

Metals coated with the latex have

KNOW YOUR ALLOY STEELS . . .

This is one of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many who may find it useful to review fundamentals from time to time.

Steel

for Strength
. . . Economy
. . . Versatility

Determining the Proper Depth of Case in Alloy Steels

In one of the recent articles in this series we discussed the carburizing of alloy steels, pointing out that the purpose of carburizing is to provide a hard, abrasion-resistant outer shell or "case." Such a discussion naturally gives rise to the question, What factors influence the choice of case? Should it be shallow? Medium? Deep or extra-deep?

While it is not always wise to formulate hard-and-fast rules, the following may be used as a general yardstick:

Shallow cases (less than 0.02 in.). Suitable where wear-resistance alone is the chief requirement, and where good surface condition after heat-treating is advantageous. Not suitable if high stresses are apt to be encountered in service.

Medium cases (0.02 to 0.04 in.). For high wear-resistance. Will stand up under substantial service loads and stresses. The thickness is sufficient to permit certain finishing operations, such as light grinding.

Medium-to-deep cases (0.04 to 0.06 in.). For high wear-resistance. A case in this depth range is essential where continuing friction is involved, especially friction of an abrasive or semi-abrasive nature. It is also a good precautionary measure where application of the finished part may sometimes involve crushing action.

Extra-deep cases (more than 0.06 in.). Cases of this depth can be obtained by extending the furnace time in pack carburizing. Highly wear-resistant, extra-deep cases also withstand shock and impact. A large camshaft of an internal-combustion engine is a good example of a part requiring the extra-deep case. This is especially true of the cam lobes themselves.

If you need advice concerning case-hardened parts, let us arrange for one of our metallurgists to assist you. Bethlehem engineers are always on call, and you can depend on their recommendations. And you can depend on Bethlehem, too, when you need alloy steels; for Bethlehem makes the full range of AISI standard grades, as well as special-analysis steels and all carbon grades.

This series of alloy steel advertisements is now available as a compact booklet, "Quick Facts about Alloy Steels." If you would like a free copy, please address your request to Publications Department, Bethlehem Steel Company, Bethlehem, Pa.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA. *Export Sales:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

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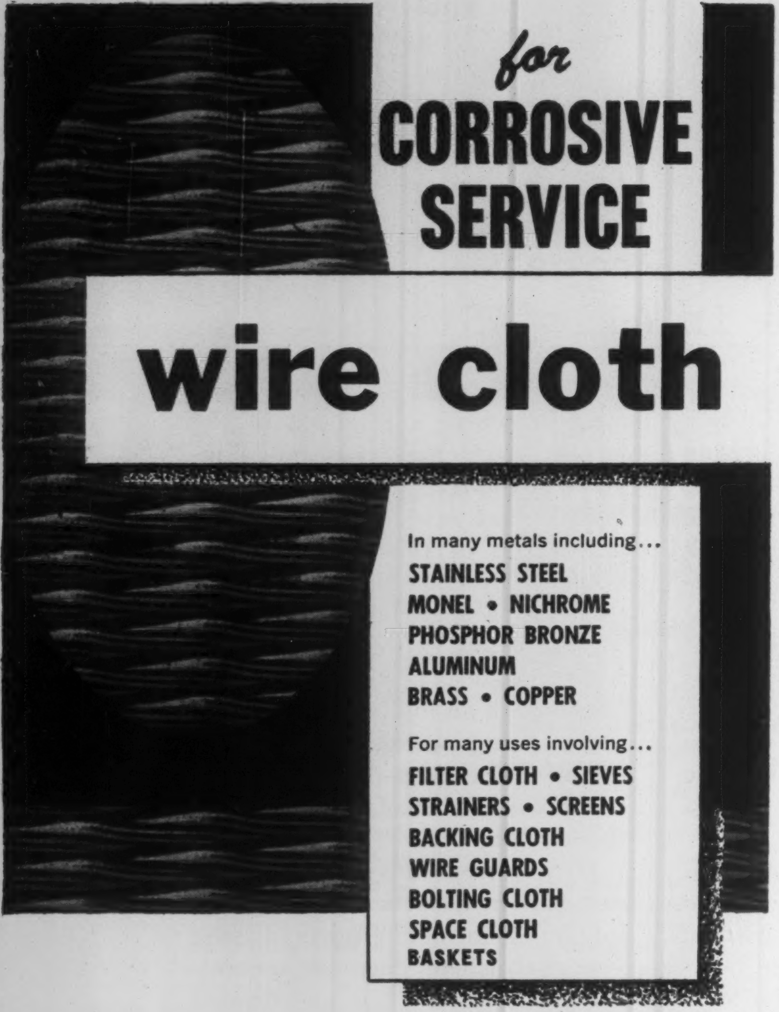

for
CORROSIVE SERVICE
wire cloth

In many metals including...
STAINLESS STEEL
MONEL • NICHROME
PHOSPHOR BRONZE
ALUMINUM
BRASS • COPPER

For many uses involving...
FILTER CLOTH • SIEVES
STRAINERS • SCREENS
BACKING CLOTH
WIRE GUARDS
BOLTING CLOTH
SPACE CLOTH
BASKETS

If you have a tough corrosion problem and need wire cloth or wire cloth parts, here's a source of supply that knows the answers. We are proud of the quality of our cloth...accurate mesh count, close tolerance wire diameter, precision weaving...plus the know-how necessary to specify the proper alloy for **your** service conditions.

NEWARK *for* ACCURACY

Write or call us today if you have a problem calling for anti-corrosive wire cloth or wire cloth parts. Send for Bulletin F-C.

Newark Wire Cloth
COMPANY
351 Verona Avenue • Newark 4, New Jersey
Teletype: NK607 • Tel.: HUmboldt 3-7700
Representatives in all principal industrial areas

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shown no traces of corrosion after 100 hr of continuous exposure to salt spray. Water immersion tests have produced equally good results, according to Goodyear.

Other advantages of the material are excellent adhesion to steel before and after water immersion and good shelf aging when pigmented. Because no solvents are present in the latex, fire hazards are practically eliminated. **KEY NO. 619**

Noted briefly in our June issue.

2. Polyethylene latex

The polyethylene latex is now available in semicommercial quantities from Spencer Chemical Co., Dwight Bldg., Kansas City 5, Mo.

The latex, called Poly-Em, is a milky, odorless liquid containing 40% solids. Presently used low molecular weight polyethylene waxes contain 30% or less solids when emulsified. Also, the new latex is harder, tougher and more flexible than conventional polyethylene waxes since it has higher molecular weight.

According to the developer, coatings of the new latex give good moisture protection to paper, and the coated paper can be printed and heat sealed satisfactorily.

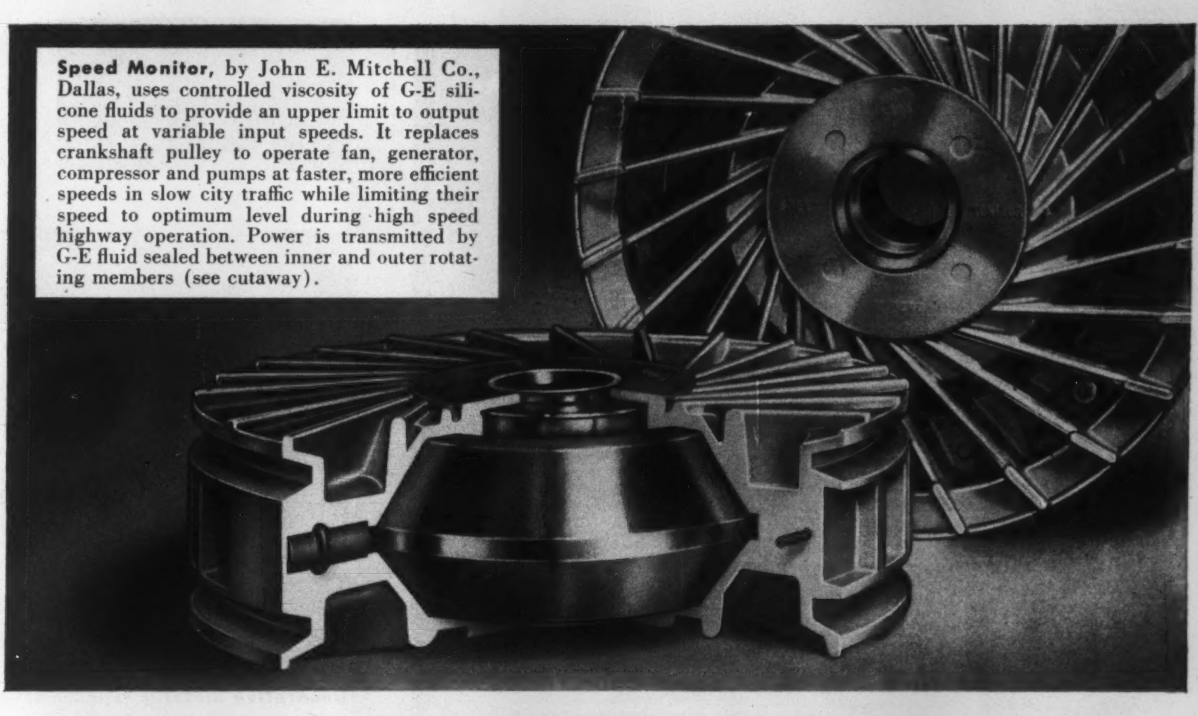
KEY NO. 620

Colored Electroplates Brighten, Protect Metal

Multicolored electroplated finishes on textured metal surfaces are said to offer a new solution to the problem of creating extra-durable decorative finishes on metals. The colored electroplates are buffed to remove the top coat from raised areas, displaying and accenting the underlying metal against a background of the electroplated deposit.

The developer, Metal & Thermit Corp., Rahway, N. J., says a variety of decorative effects can be achieved by varying the basis metal, the electroplating process and/or the texturing method.

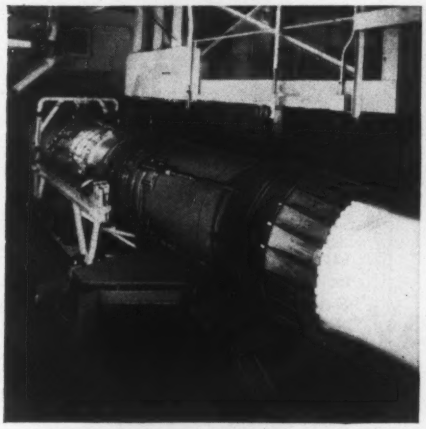
For example, when textured steel is zinc-plated and dyed with chromate conversion coatings, buffing causes the bright zinc to stand out in relief against the colored chromate conversion coating in the recesses. *(continued on p 198)*



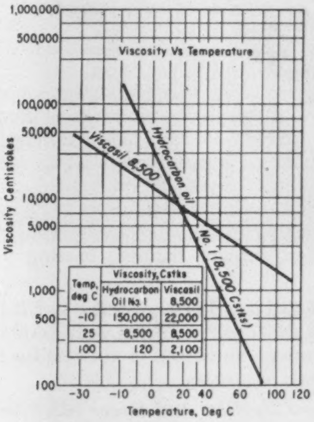
Speed Monitor, by John E. Mitchell Co., Dallas, uses controlled viscosity of G-E silicone fluids to provide an upper limit to output speed at variable input speeds. It replaces crankshaft pulley to operate fan, generator, compressor and pumps at faster, more efficient speeds in slow city traffic while limiting their speed to optimum level during high speed highway operation. Power is transmitted by G-E fluid sealed between inner and outer rotating members (see cutaway).

GENERAL ELECTRIC SILICONE FLUIDS

for reliable performance under tough operating conditions



Thermal stability. The outstanding thermal and oxidative stability of G-E silicone fluids, over an operating temperature range of −100°F to 600°F, makes them suitable for such rigorous applications as jet engine lubricants and aircraft hydraulic fluids. G-E Versilube fluids give unequalled performance at high temperatures and are comparable to other hydraulic fluids in moderate ranges.



Temp, deg C	Viscosity, Cstks	
	Hydrocarbon Oil No. 1	Viscosil 8,500
-10	150,000	22,000
25	8,500	8,500
100	120	2,100

Nearly constant viscosity over wide temperature range. G-E silicone fluids exhibit very small changes in viscosity with wide temperature variations. This makes them ideal for many mechanical applications, including fluid drives, dash pots, vibration dampers, timers, shock absorbers, or wherever constant viscosity is needed.

Silicones product data
Silicones product data
VISCASIL
SILICONE FLUIDS
FOR MECHANICAL APPLICATIONS
GENERAL ELECTRIC

Get the complete story. These bulletins give complete technical data on the G-E silicone fluid line and describe many of the ways in which designers are taking advantage of their outstanding properties. For your free copies, write to Department B953, General Electric Company, Silicone Products Department, Waterford, N. Y.

GENERAL ELECTRIC

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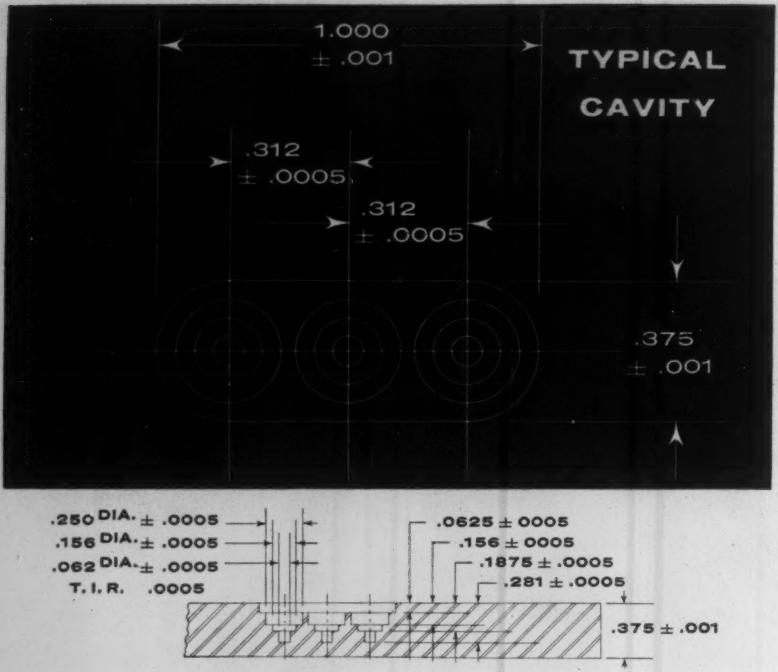

UNBELIEVABLY CLOSE TOLERANCES

on graphite jigs and fixtures
. . . but Speer can hold them!

Here are a few examples—
- **Concentricity of drill holes to .0005 T. I. R.**
- **Drilled holes as small as .005 held to ± .0005**
- **Depth of holes held to ± .0005**
- **Oblong or "pork-chop" type cavities—length and width held to ± .001, depth held to ± .0005**

Combine Speer's superb machining skill with the wonders of Speer Graphite itself and you have the perfect solution to many high-temperature problems. Graphite actually gets *stronger* as it gets hotter . . . does not warp . . . will not split or break down under severe thermal shock. It is chemically inert and is not wet by molten metal or glass. Speer Graphite is the ideal material for many high-heat applications, such as transistor jigs, fusing positioners, honeycomb jigs, furnace fixtures, brazing jigs, glass-to-metal seals.

BRING YOUR PROBLEMS TO SPEER! Years of experience in solving tough high-temperature forming and positioning problems with graphite, plus Speer's unusual fabricating skill, provide hundreds of answers for the aircraft, electronics and powdered metals industries.

To obtain full information on Speer Graphite and Speer machining facilities in relation to your specific requirements, send us your detailed blueprints. Your inquiry will receive prompt attention.

SPEER Carbon Co.
CARBON PRODUCTS DIVISION
ST. MARYS, PENNSYLVANIA

Products of the Carbon Products Division include:

Brushes for Motors & Generators • Carbon & Graphite Specialties • Electronic Tube Anodes • Flashlight & Battery Carbons • Plates & Rods • Rocket & Missile Components • Ultra Pure Graphite

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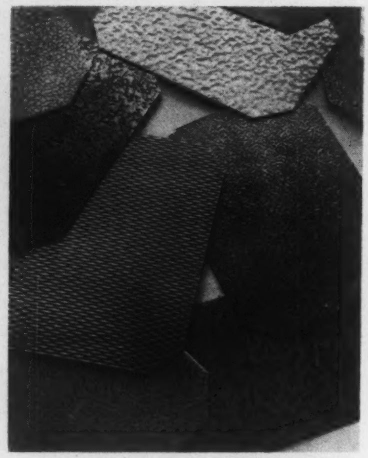


Decorative metal *is expected to be used for appliance and business machine housings, and automotive trim and interiors.*

In another variation, a basis metal is plated in a cold chromium plating bath. On buffing, contrasting lighter gray shades are produced on raised areas while the dark gray deposit remains in the recesses.

Noted briefly in our July issue.

KEY NO. 621

Thermoplastic Has Good Heat Resistance

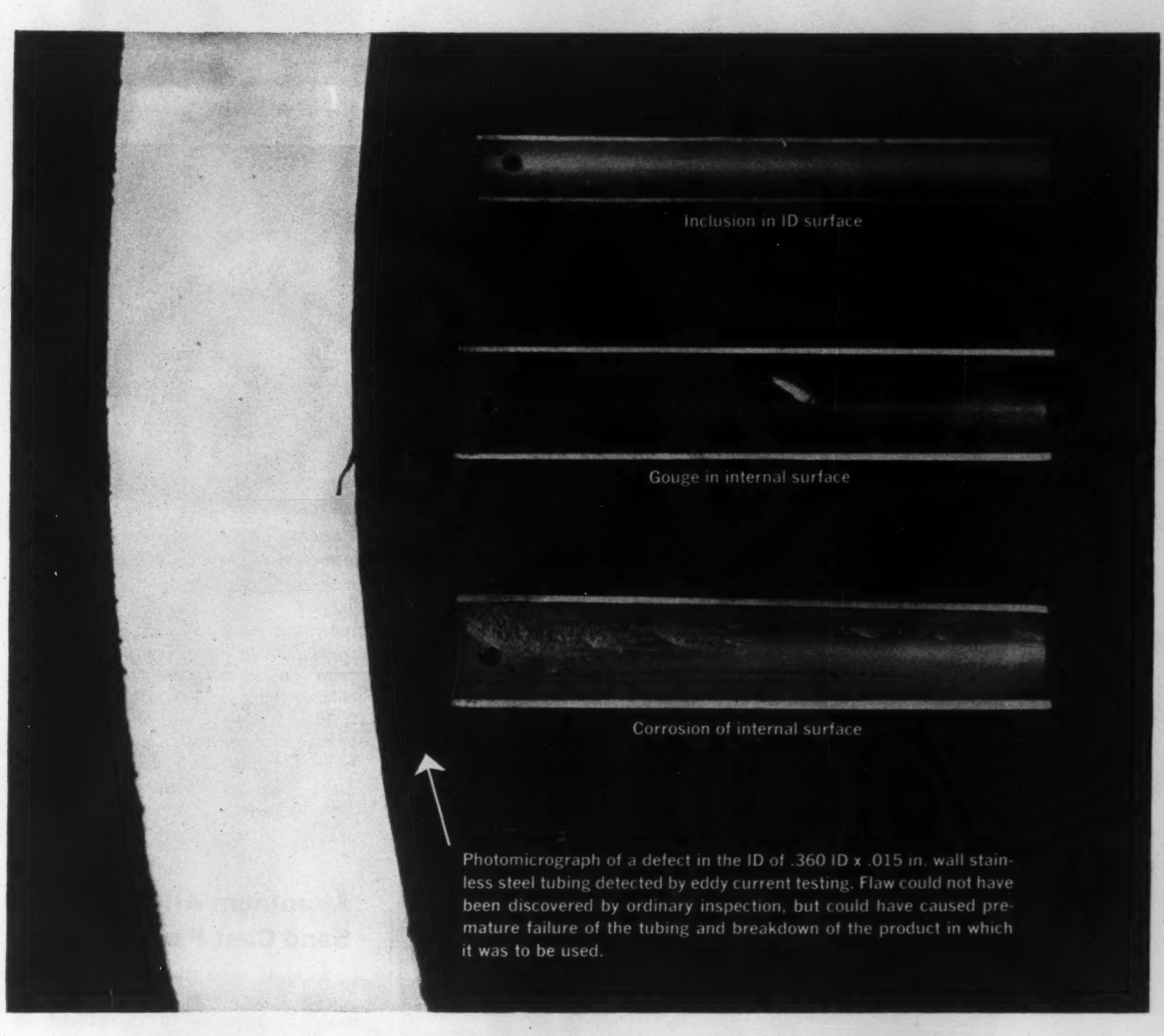
Commercial availability of a crystal clear, acrylic-type thermoplastic has been announced by J. T. Baker Chemical Co., Phillipburg, N.J. The resin, called Bavick-11, sells for $1 per lb in lots of 80,000 lb or more. It was introduced two years ago under the name PL-11 (M/DE, Apr '59, p 154).

According to the producer, Bavick-11 has the highest heat and solvent resistance of all clear plastics. It does not warp or distort at temperatures up to 248 F, and is especially resistant to alcohols, mineral acids, strong alkalis, aliphatic hydrocarbons, fatty acids, organic acids, essential oils and detergents.

The resin does not crack, craze or blush after being chilled on dry ice, then heated with boiling water while still on the ice. Transparency is unaffected after continuous immersion in boiling water.

Some potential applications are

Tomorrow's tubing technology — today



Photomicrograph of a defect in the ID of .360 ID x .015 in. wall stainless steel tubing detected by eddy current testing. Flaw could not have been discovered by ordinary inspection, but could have caused premature failure of the tubing and breakdown of the product in which it was to be used.

Tubing Quality Verified by Nondestructive Tests

Superior tubing for critical applications must be consistently of highest quality and reliability. As a consequence, nondestructive testing is essential. Furthermore, several types of test should be performed, since no one test is versatile enough to supply all the required information.

Eddy current spots defects we don't want in Superior tubing, but it doesn't tell us everything about them. Neither does any one of the other seven nondestructive tests we use in checking the finished quality of our tubing.

Depending on how critical the end use of the tubing is and thus the amount of test information required, we can perform any of the following tests singly or in combination: eddy current, dye penetrant and fluorescent dye penetrant, ultrasonic, radiographic, hydrostatic, boroscopic and magnetic particle. Only in this way can we detect imperfections such as change in analysis and dimension, pits, roughness, inclusions, weld defects, carburization, porosity, corrosion, laps, embedded particles, and surface oxides on OD and ID and in the wall of the tubing.

An article, "Nondestructive Testing of Small Tubing," details and compares the methods used. If you would like a copy, and technical data on the more than 120 analyses of small-diameter tubing produced in our mill, write us. Superior Tube Company, 2006 Germantown Ave., Norristown, Pa.

Superior Tube
The big name in small tubing
NORRISTOWN, PA.
West Coast: Pacific Tube Company, Los Angeles, California

For more information, turn to Reader Service card, circle No. 419

TIN COATING from .00002 to .0025

Somers THIN STRIP

For the first time tin coated thin strip is available in solderable coatings up to .0025" thick.

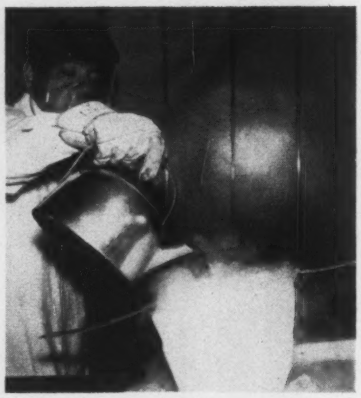
Pure tin and tin-lead alloys are now coated on copper, brass, or nickel in all gauges from .002 to .012 in thicknesses of .00002 to .0025.

Over 50 years experience in the highly specialized field of thin strip makes Somers your #1 source for that one job in ten that must meet rigid specifications. Write for confidential data blank to get the exact thin strip for your requirements — no obligation, of course.

Somers Thin Strip

SOMERS BRASS COMPANY, INC. • 94 Baldwin Ave., Waterbury, Conn.

For more information, turn to Reader Service card, circle No. 396



Pouring *boiling water on chilled specimen of Bavick-11 does not cause it to crack or craze.*

indicator lamp covers, pointers, dial faces, bottle tops, escutcheons and trim on electric ranges, and percolator tops.

The material can be molded, extruded, machined, polished, lacquered, painted, hot stamped, metallized, dip-dyed, cemented and solvent welded. **KEY NO. 622**

Aluminum Alloy for Sand Cast Parts

A high strength, shock and corrosion resistant aluminum sand casting alloy has been introduced by William F. Jobbins, Inc., Aurora, Ill. The alloy contains about 6.5% zinc and about 0.70% magnesium in addition to other alloying elements.

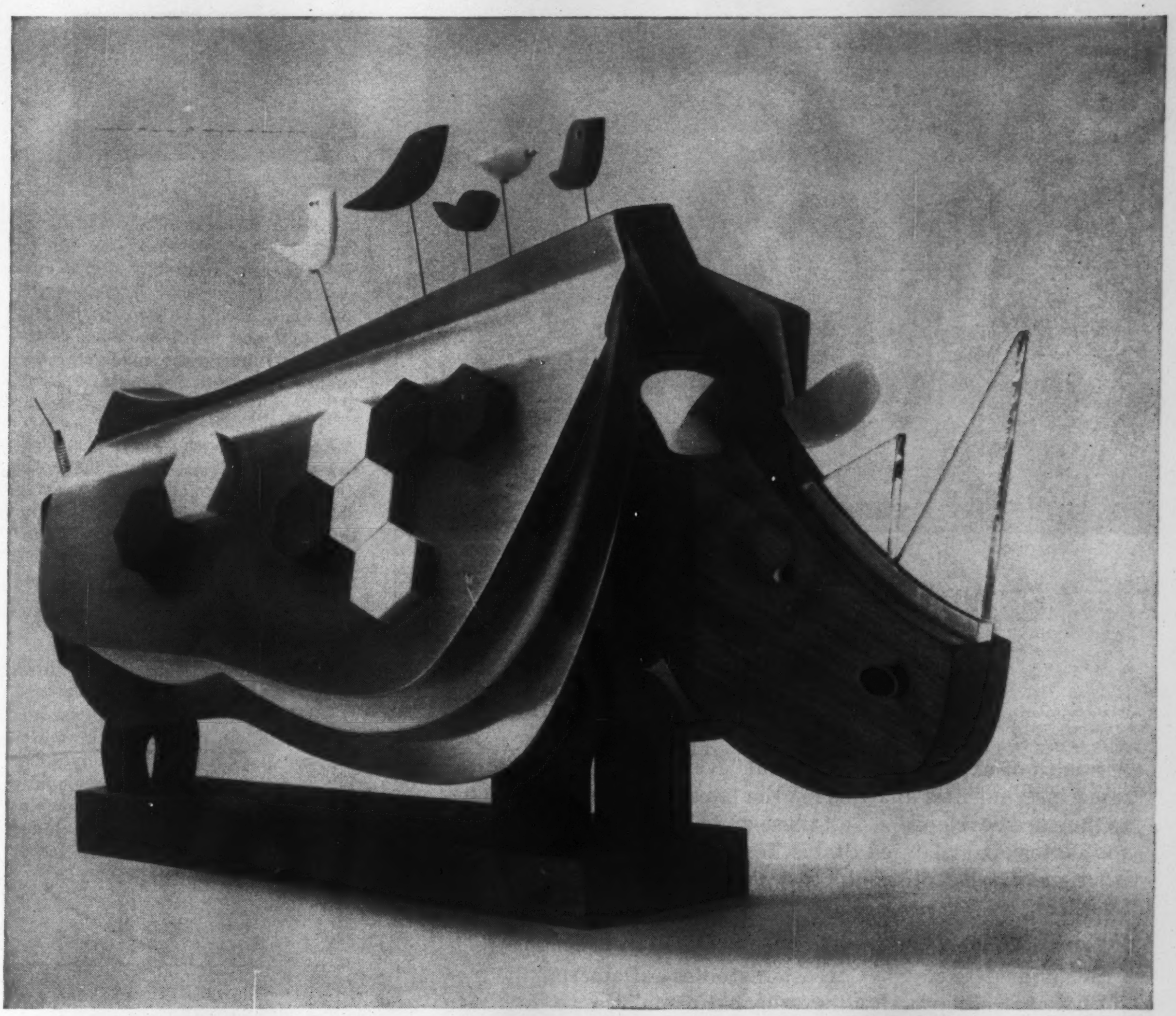
Sold in two grades

The alloy, called Precedent 71, is sold in two grades:

71A has a yield strength of 36,000 psi and some degree of shock resistance in the as-cast and fully aged conditions. It has a yield strength of over 40,000 psi and an elongation of over 5% in the solution heat treated and T6 condition.

71B has a yield strength of 32,000 psi and an elongation of 7% in the as-cast and fully aged condition, combining high yield strength with good shock resistance.

The developer says that both grades become completely stress-free and develop full mechanical proper-



Sculpture created especially for 3M Company by Guy Palazzola

STRENGTH

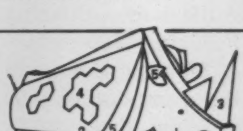
. . . Bonds "strong as a bull rhinoceros" made with SCOTCH-WELD®
Brand Structural Adhesives

Whatever materials you're bonding (to the same or to another material), a SCOTCH-WELD Brand Structural Adhesive bond will give you a bonus of structural strength at the joint, with the flexibility to resist vibrational fatigue. SCOTCH-WELD adhesive bonds distribute stress loads uniformly, and protect the strength and integrity of the materials by eliminating fastening holes, maintaining the finish, and sealing joints against corrosion.

Fatigue tests show that metal-to-metal joints in Convair's 880 jet transports and Air Force F-102A jet interceptors, bonded with SCOTCH-WELD adhesives, will outlast the metal structure they bond together! In industry, too, SCOTCH-WELD adhesives are finding use in joining hermetically sealed metal shipping containers, multiple piece castings and thinner gauge metals, where tear strength would limit the effectiveness of other joining methods.

Look first to 3M! A pioneer in adhesive research, 3M has developed the widest line of adhesives in the industry. These Technical Service facilities are at your disposal. For an accurate appraisal of how an adhesive can add strength, light weight, production economy, and greater design freedom to your process or product, call your nearest 3M Field Engineer or write to: AC&S Division, 3M Company, Department SBHH-91, St. Paul 6, Minnesota.

"SCOTCH-WELD" is a Reg. T.M. of 3M Co. © 3M Co., 1961.



What do you want to bond to what?
The 3M Rhino is fabricated of these materials and bonded with SCOTCH-WELD Brand Structural Adhesives:
1. Wood 2. Aluminum 3. Glass 4. Ceramic 5. Plastic 6. Permanent Magnet 7. Brass

ADHESIVES, COATINGS AND SEALERS DIVISION
MINNESOTA MINING AND MANUFACTURING COMPANY
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3M COMPANY

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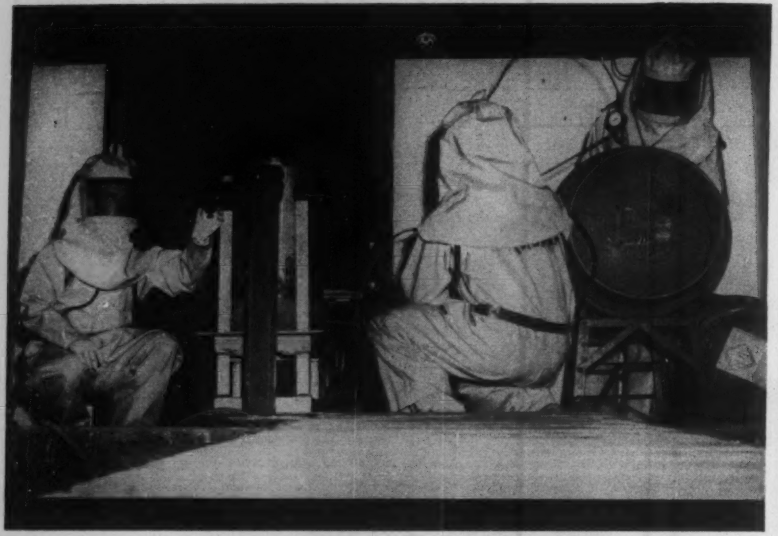

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ties after stress relieving at 700 F. Both grades are also said to be dimensionally stable to 0.00001 in. per in. after stress relieving. Castings made from the two grades can be rough and finish machined without interrupting the machining sequence for stress relieving.

Can be brazed at 1125 F

According to the developer, Precedent 71 alloys are not permanently affected by furnace or dip brazing at 1125 F. Conventional aluminum sand casting alloys usually disintegrate at this temperature. The two grades can be aged at room temperature to restore them to their full physical and mechanical properties after brazing.

The new aluminum sand casting alloy is dimensionally stable and machinable on the day it is cast and stress relieved. Other self-aging aluminum alloys require a 21-day aging period before they are dimensionally stable and hard enough for machining. The new alloy can be machined at speeds up to three times faster

PROPERTIES OF PRECEDENT 71 ALLOY[a]

GRADE ➡	A	B
AS CAST		
Ten Str, 1000 psi		
1 Day Old	36	34
6 Month Old	44	40
Yld Str (0.2% offset), 1000 psi		
1 Day Old	20	16
6 Month Old	36	32
Elong (in 2 in.), %		
1 Day Old	11	15
6 Month Old	3	7
Brinell Hardness		
1 Day Old	70	64
6 Month Old	93	88
STRESS RELIEVED		
Ten Str, 1000 psi		
1 Day Old	32	30
6 Month Old	43	40
Yld Str (0.2% offset), 1000 psi		
1 Day Old	16	15
6 Month Old	33	31
Elong (in 2 in.), %		
1 Day Old	12	14
6 Month Old	3	6
Brinell Hardness		
1 Day Old	61	60
6 Month Old	96	90

[a] Tests conducted on 0.505-in. dia cast-to-size specimens not machined.

the LEAD *newsletter*

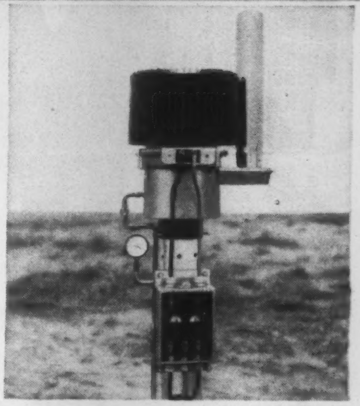
Vol. 3 No. 3

Space-vehicle uses for lead have triggered a vigorous chain reaction among product design engineers with an eye to more down-to-earth markets.

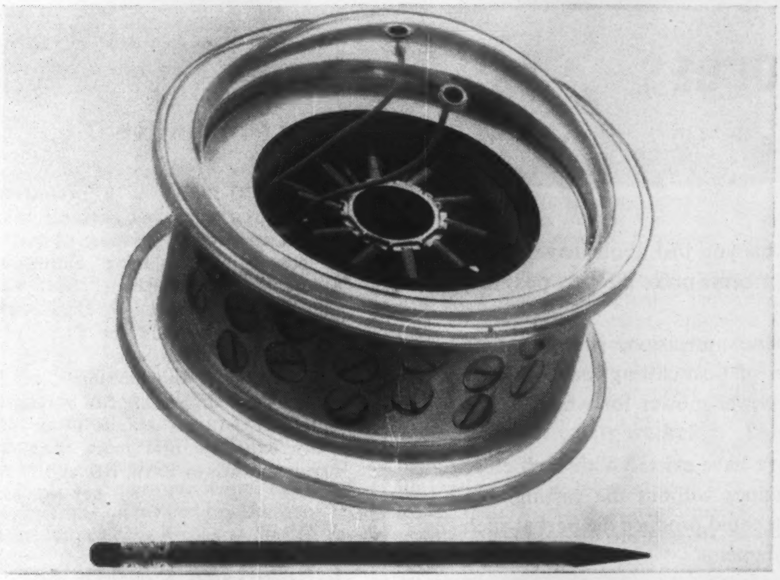
Envisioned – or already demonstrated to be practical – are gas- and oil-fired home heating units that generate their own electricity to provide power for fans, blowers, and pumps; continuous charging of automobile batteries without a generator; power for many uses remote from utility lines, or produced from waste heat sources.

Lightweight Power Source

First practical demonstration of direct conversion of atomic reaction heat to electric current was provided by the SNAP III power package (illustrated), a device introduced in 1959 to power communications equipment in satellites and space vehicles. Weighing just 5 pounds, it produced 10,000 watt hours over 280 days. If The Atlas "talking satellite," orbited December 1958, had such equipment, it could have sent continuous signals for several months.



Cathodic Protection Service



Thermoelectricity via Lead Telluride

Basic to these advances is thermoelectricity, a phenomenon which manifests itself in two opposite ways. The first occurs when current is passed through a thermoelectric material: one end of the material gets hot, the other cold. This is the "heat pump" effect, the principle of thermoelectric refrigeration. But if heat is applied to one end of such material, power is generated.

The efficiency of a material in these uses – what solid state physicists call its "figure of merit" – depends on the temperature range of application. In the temperature range most useful for power generation (350° to 1250° F.) the most effective substance yet discovered is *lead* telluride.

Protects Gas Mains and Truckmen

A thermoelectric generating unit using lead telluride is being used to power cathodic protection systems on gas mains. Burning gas from the mains supplies the heat. Tests show that electricity from lead telluride is actually cheaper than from power lines.

Another use of lead telluride elements is in a truck cab heater now available. Fueled by L-P gas, it enables drivers to sleep in heated cabs without danger of carbon monoxide fumes from running motors. Such elements are also used in detector heads of a monitored fire protection system, allowing more rugged, dependable, and efficient installations.

Applications are Growing

Lead telluride generators in an actual power package have conversion efficiencies around 7 to 9%, with 12% efficiency predicted by the Dept. of Commerce for 1962. While not enough to compete with big land-based utilities, it's ample to carve out a real commercial market for these devices as auxiliary power and portable power packages. Several large appliance makers are among those now researching additional applications.

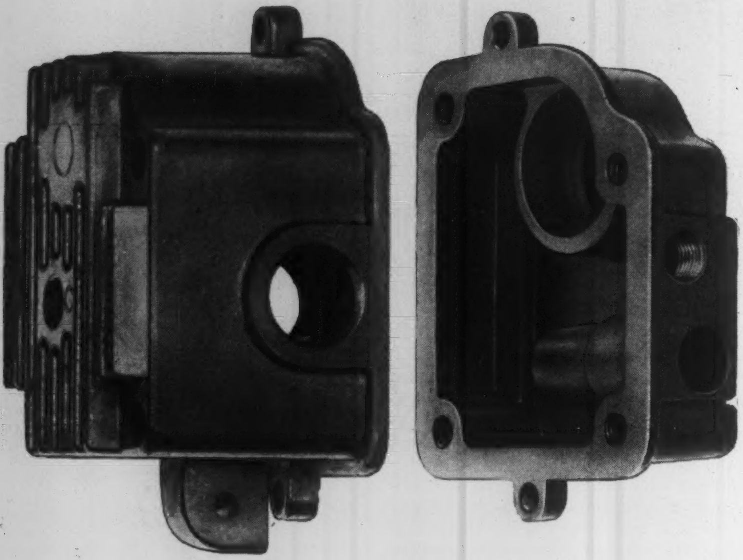
One company predicts that, with volume production, cost of thermoelectric power can be cut below $1 a watt. Portable power supplies in the 5 to 10 kilowatt range are being developed right now. Units generating 100 to 1000 kilowatts are considered feasible by 1965. Trickle charging systems for lead acid batteries are one particularly attractive possibility that should make a battery system more competitive, create many new applications.

Lead is keeping pace with new technology in many fields. For technical information and help in applying lead to your own products and problems, simply write: Office of Technical Information, Lead Industries Association, 292 Madison Ave., New York 17, N. Y.

4480

LOOK AHEAD WITH LEAD

For more information, turn to Reader Service card, circle No. 385



Which came first, the process or the part?

When you see a die casting like this you just about have to ask yourself . . . "Did the production process make the part possible, or did design dictate the process?"

Part-wise this gear box demands precision, strength, heat dissipation, maximum elimination of post-casting machining. It is integral and functional to the power mower for which it was built. Did design dictate die casting?

Process-wise, the shape couldn't have existed with such close tolerances, with such variable shapes without die casting. No known method of parts production could produce the part at such low unit cost and maintain requirements.

Perhaps this is the way to look at it: Good part design and good die casting *combine* for superior results. Since 1919, Twin City Die Castings has aimed its complete plant facilities to achieve this end.

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For more information, turn to Reader Service card, circle No. 438

COMPOSITION OF PRECEDENT 71 ALLOY (%)

Grade ➡	A	B
Zinc	6.5 -7.5	6.0 -7.0
Magnesium	0.65-0.85	0.55-0.75
Chromium	0.06-0.15	0.06-0.15
Titanium	0.10-0.25	0.10-0.25
Silicon	0.15 max	0.15 max
Iron	0.15 max	0.15 max
Copper	0.10 max	0.10 max
Manganese	0.10 max	0.10 max
Aluminum	Balance	Balance

than aluminum-silicon alloys.

Castings made from the alloy polish to a chrome-white finish and anodize to a satin-white finish by the sulfuric acid process.

KEY NO. 623

Noted briefly in our June issue.

Rust Preventive Oil

A new rust preventive oil called Entek RPO-12 leaves a protective film on iron and steel surfaces that is said to prevent rusting of parts in storage and during shipment. Available from Enthone, Inc., 442 Elm St., New Haven 8, Conn., the rust preventive sells for $1.85 per gal in 55-gal drum lots.

According to the developer, plain carbon steel dipped in full strength Entek RPO-12 withstands 40 hr salt spray exposure and more than 45 days exposure to 100% RH at 100 F.

KEY NO. 624

Fiberglass Roving for Spray Gun Application

A new fiberglass roving has been designed for use in spray guns in which resin and fiberglass are sprayed simultaneously on a mold or form. The roving, designated 7170, is available from Johns-Manville Corp., Glass Textiles Div., 1810 Madison Ave., Toledo 2, Ohio.

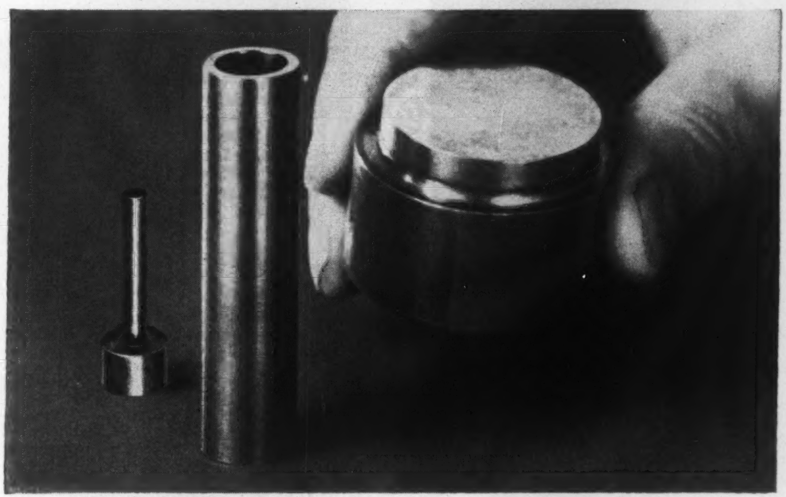
Static-free and featuring fast wet-out, the roving is expected to be used in the fabrication of glass-reinforced plastics boats, tank linings, swimming pools and temporary shelters.

According to the producer, the quick wet-out action of the roving

Linde *materials & Coatings* News

LINDE COMPANY, DIVISION OF UNION CARBIDE CORPORATION

Crystal tungsten opens up a new era for the metal in electronics



Typical electronic shapes fabricated from crystal tungsten (l. to r.): target emitter; zero-porosity tungsten anode for high-powered electron tubes with fluid cooling; high-power vacuum switch contact of zero-porosity tungsten mounted to copper.

A new method of consolidating tungsten powder into tungsten ingot has been created by LINDE's Crystal Products Department. This new material—in crystal form—changes the whole approach to use of tungsten in electronic applications.

Compared to metallurgically prepared (PM) tungsten, crystal tungsten offers 5 to 15 per cent higher electrical conductivity. Thermal conductivity is about 20 per cent higher at 500°F., resulting in improved heat dissipation. These properties can be advantageous in electronic design.

Useful in vacuum devices

The high purity and zero porosity of the crystal tungsten also suggest its use not only in electrical contact points, but also in vacuum switches, electrical lead-ins in vacuum tubes, and applications where outgassing or leakage is a problem. Their purity and lack of grain boundaries provide more even electron emission, making them valuable in several high pressure vacuum or open air switches. Other uses include: flexible sheet in electronic tubes; x-ray and anti-cathode targets.

LINDE crystal tungsten is considerably more ductile than undoped PM tungsten. It can be drawn into wire as fine as 1 mil, giving greater yield of finished product from the starting ingot. Although undoped crystal tungsten has a lower recrystallization temperature, it does have a yield point at about 150°F.

Material easily worked

Significant is the fact that it can be easily worked and at temperatures 800°F. lower than working temperature for powder metallurgy or vacuum-arc cast tungsten—making it useful for a wide range of non-electronic applications. Present shapes include swaged rods from 1/10 to ⅜-inch diameter, as grown ingots up to ¾-inch diameter in production, and even larger diameters in development.

For more details on this new material, check the coupon below.

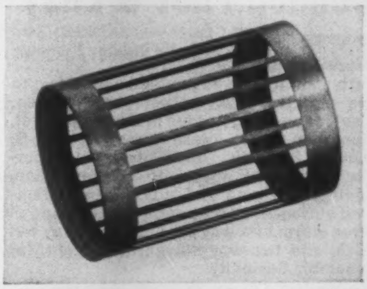
Super-hot process metal-coats and fabricates intricate parts

Dense, high-purity metal coatings for certain base materials, and the fabrication of odd shapes, are accomplished with "Plasmaplate," a super-hot plasma stream process developed by LINDE's Flame-Plating Department.

In operation, a high-current torch uses temperatures up to 30,000° F. to produce a supersonic stream of ionized gas—melt and accelerate to high velocity particles of any inorganic material that melts without decomposition.

High-purity coating materials—such as tungsten or other refractory metals—are thus permanently fused to the surfaces of materials such as graphite, brass, copper, steel, molybdenum, titanium, aluminum and others.

Parts of intricate configuration can be fabricated by depositing the coating material on a mandrel machined to the desired internal shape of the finished part. After the desired thickness is obtained, the mandrel is dissolved out by chemical means.



Tungsten grid cage—one of many complex shapes made by LINDE's "Plasmaplate" Process.

Thin coatings of tungsten carbide and other hard materials can also be applied to base metals by the LINDE oxyacetylene Flame-Plating "gun" process, to increase surface wear as many as 40 times.

For details on either of these LINDE processes, check the coupon below.

CHECK—CLIP COUPON—ATTACH TO BUSINESS LETTERHEAD

Linde Company, Dept. MI-09
270 Park Avenue
New York 17, N. Y.

Please send details on the items checked:

☐ LINDE Crystal Tungsten
☐ LINDE "Plasmaplate" Process
☐ LINDE Flame-Plating Process

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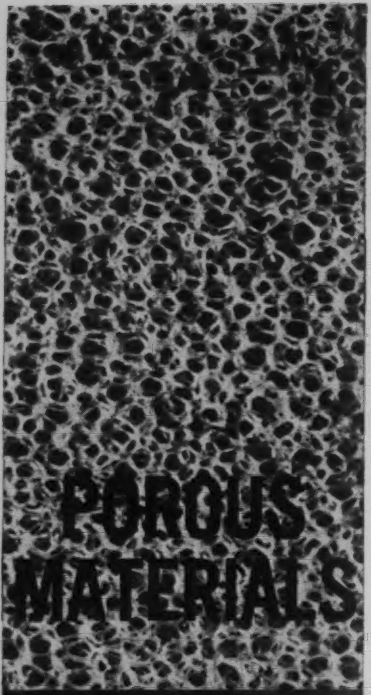

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Bostik #1142 Synthetic Rubber Adhesive

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Bostik #1142 is available from stock, as are related numbers designed to meet specific requirements. Technical assistance readily given to solve bonding problems.

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What's new IN MATERIALS

Operator *lays down new fiberglass roving on a small boat hull. The clean chopping, nonclumping qualities of the roving are said to give uniform coverage.*

speeds up the process, since the fiberglass immediately starts to soak up resin while still flying toward the mold or form. The static-free quality of the roving insures that all strands lay down flat on the mold.

KEY NO. 627

Superconductive Wire for Less Bulky Magnets

A new columbium-zirconium alloy is said to offer "no resistance to electrical current at liquid helium temperatures."

The developer, Atomics International, Div. of North American Aviation, Inc., P. O. Box 309, Canoga Park, Calif., says superconductive magnets made of the alloy could replace conventional bulky and relatively inefficient iron-core electromagnets in many applications. In space applications superconductive magnets could store more electrical energy in less space than conventional electrical capacitors.

A wire drawn from the material has conducted 100,000 amp per sq cm in a moderately high magnetic field (30,000 gausses) at −452 F. Such performance is comparable to the operation of a household appli-

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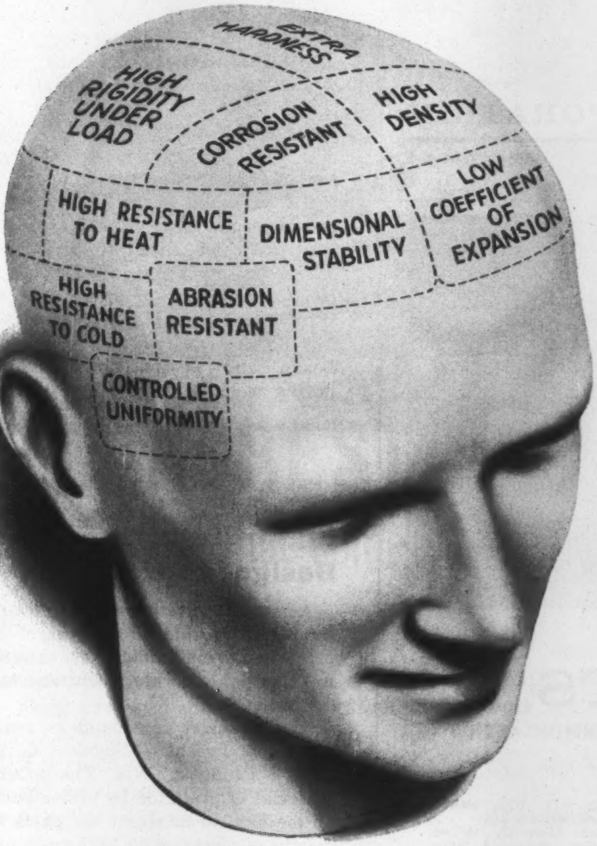
"Whatever the mind of man can conceive and believe, the mind of man can achieve..."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For more information, turn to Reader Service card, circle No. 472

ance at about 100,000 w from a 110-v wall outlet.

The new alloy, approximately three parts columbium and one part zirconium, is malleable and strong. It can be made into wires, bars, strips and other shapes without losing its superconducting properties.
KEY NO. 628

Polycarbonate Resin Is Nearly Water Clear

A new grade of polycarbonate resin is designed for lenses, light covers, diffusers, inspection ports, safety goggles, knobs, pipe, tubing and other parts requiring clarity.

Identified as Lexan 102, the resin is available from the Chemical Materials Dept. of General Electric Co., Pittsfield, Mass. It sells for $1.30 per lb in truckload lots, the same as for other grades of Lexan resin.

GE says the nearly water clear polycarbonate has the same physical, electrical and chemical properties offered by other grades of polycarbonate resin. Its improved clarity results from use of additives masking the natural light amber color of Lexan and preventing darkening during molding. **KEY NO. 629**

Noted briefly in our March issue.

Rigid Urethane Foam Designed for Potting

A new rigid urethane foam potting compound is said to give excellent protection to electronic parts exposed to thermal shock, vibration and dampness.

The two-part compound is available from Freeman Chemical Corp., Port Washington, Wis. The potting material is prepared by either batch or mechanical mixing: 100 parts by weight of Chempol 30-1322 resin and 118 parts of Chempol 30-1426 resin. The mixture is then poured into a void to be potted and allowed to foam and cure.

Rigid urethane foam produced from the resins is said to have excellent dimensional stability at both

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• Graphite Specialties Corporation can produce graphite sufficiently pure for moderating nuclear reactors; or with required properties to provide an exceptionally low erosion rate in rocket nozzles; or with corrosion resistance values to permit use with chlorine at *any* temperature.

In addition, other special types are available for crucibles for transistor crystal growth, difficult metallurgical and chemical applications, as well as for mechancial equipment component parts.

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• Write today for information relating to your specific requirements to Graphite Specialties Corporation, Blank & Walmore Roads, R.R. 2, Sanborn, New York. Phone Republic 1-3226.

For more information, circle No. 386

PROPERTIES OF URETHANE COMPOUND

Ther Cond (k factor), Btu/hr/sq ft/°F/in.	0.25
Tensile Strength, psi	400
Shear Strength, psi	100
Flexural Strength, psi	128
Compressive Strength, psi	375

low and elevated temperatures. The foam is unaffected by a series of thermal shock cycles from 200 to −67 F. It does not crack or distort after immersion in liquid nitrogen. Heat distortion temperature is above 200 F.

KEY NO. 630

Coating for Glass Protects in One Layer

A new organic coating is said to provide a decorative and protective finish on glass in one layer; conventional coatings for glass usually require two layers. Another advantage: the glass does not have to be treated before application.

Called Sterilkote 600, the coating is available in a range of transparent and opaque colors from Bradley & Vrooman Co., 2629 S. Dearborn St., Chicago 16.

The coating is spray applied with conventional equipment and bakes at temperatures from 350 to 550 F, forming a film that has excellent resistance to acids, alkalis, detergents and solvents. The developer says the coating adheres tenaciously to glass under humid and wet conditions.

It is recommended for use on bottles, containers, shelving, lighting fixtures and drinking glasses.

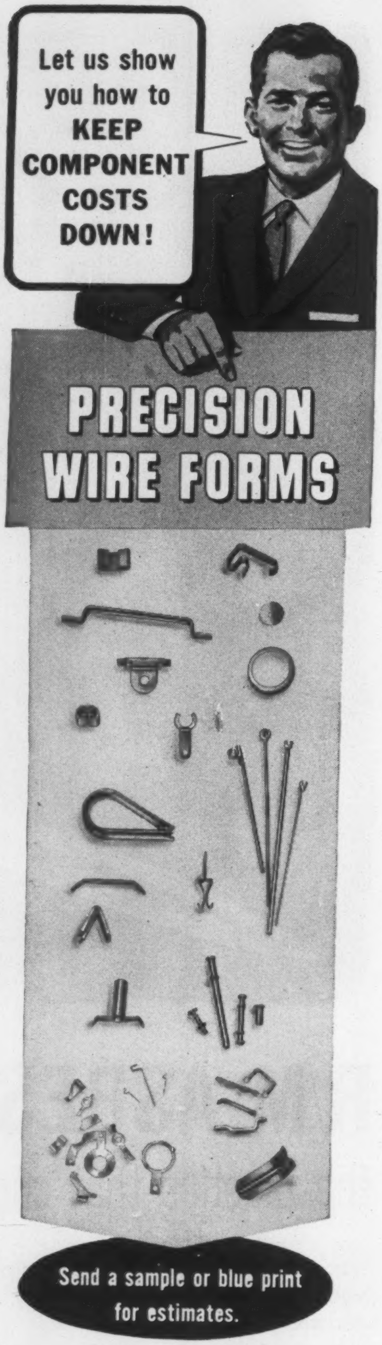
KEY NO. 631

Two Nylon 6 Resins Reduce Molding Time

Two new nylon 6 resins are said to significantly increase production rates of injection molded parts.

The resins, called No. 401A and No. 605A, are available from Spencer Chemical Co., Dwight Bldg., Kansas City 5, Mo. No. 401A is recommended for intricate or hard-to-fill molds, and No. 605A is recommended for massive parts and load-bearing parts such as gears and bearings.

The producer says that field tests



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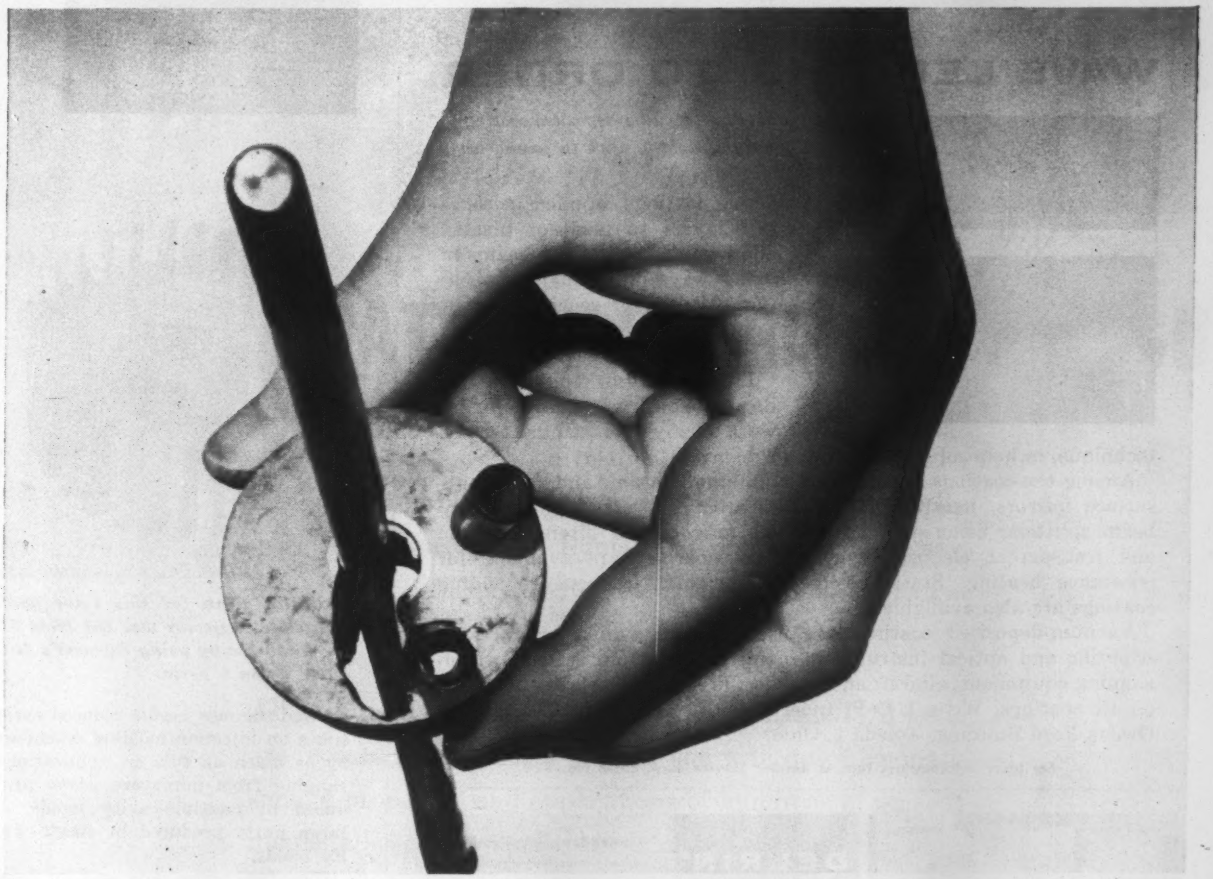
Wear like this led to replacement of 7 metal parts by ADIPRENE

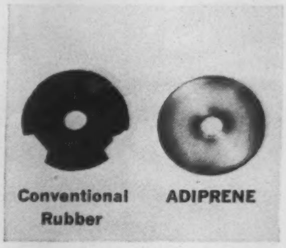


Highly abrasive glass dust caused this reciprocating rod to cut entirely through a metal bearing and most of the cylinder rod end plug in a UNIFIL® loom-winder used in glass fabric weaving. An ADIPRENE bearing was still performing well a year later, after more than 200 million strokes.

ADIPRENE® still at work after 200,000,000 strokes...on a job too tough for metal bearing

Tiny glass particles ground gaping holes in vital metal parts on glass fabric weaving equipment. An obvious solution was substitution of non-metallic parts. But when conventional rubbers and plastics were tested, failure again occurred. ADIPRENE urethane rubber, however... with its excellent resistance to abrasion, plus its combination of hardness, resilience, and load bearing capacity... tested so successfully that now seven ADIPRENE parts are used in the same loom-winding machine. These parts reduce downtime and increase quality by making possible continuous runs of the glass fabric.

ADIPRENE can help you in the design of better, longer-lasting parts. It is oil-resistant, machinable and has outstanding electrical properties. For detailed information on the unusual combination of properties of ADIPRENE, write E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Department MDE-9, Wilmington 98, Delaware.



Conventional rubbers were also tested for textile machinery parts. ADIPRENE far outlasted all metals, plastics and rubbers.

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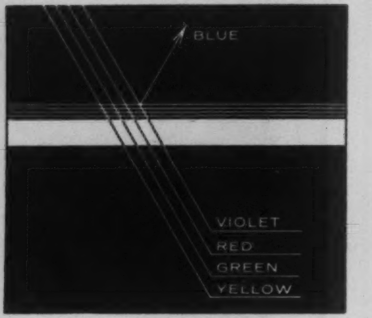


Multiple vacuum-deposited coatings can put light to work in several ways

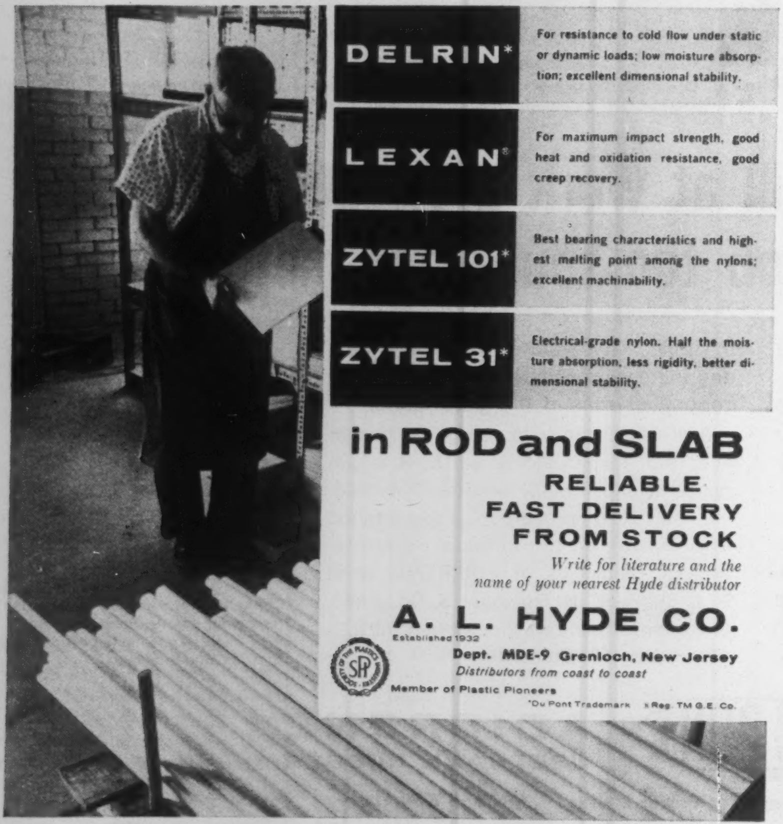
These coatings, applied in separate layers to glass or plastic, allow you to split light beams in many ways on a single application. Multilayer coatings can be applied to produce a specific beam-splitting result.

Liberty Mirror engineers can do all the design and development work on any potential use for this technique, or help solve application problems.

Among the coatings available are aluminum, chrome and gold front-surface mirrors, neutral filters, transparent mirrors, high-efficiency beam splitters, beam-splitting dichroic mirrors and filters. Metallic and transparent electrically conducting coatings are available for resistance heating. Static-dissipating and high-frequency shielding coatings are also available.

Vacuum-deposited coatings are used in such varied products as scientific and optical instruments, cameras, toys, pin setters, wheel-aligning equipment, aircraft and missiles. Free data sheets are available on all coatings. Write L·O·F, Liberty Mirror Division, 2391 Libbey·Owens·Ford Building, Toledo 1, Ohio.

For more information, turn to Reader Service card, circle No. 328



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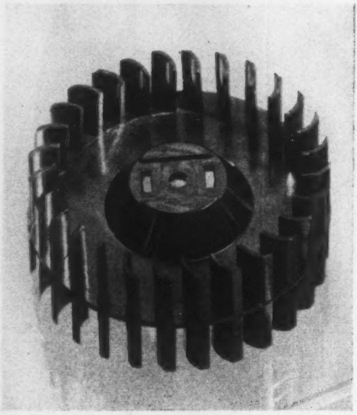
What's new IN MATERIALS



Molding time *for this rotor used in a slide projector was cut from 51 sec to 30 sec by using Spencer's No. 401A nylon 6 resin.*

showed the new resins reduced cycle times on injection molding machines by as much as 40% in applications ranging from miniature parts produced in multiple-cavity molds to large parts produced in single-cavity molds.

The two resins are said to have increased flow and require lower ram pressures and less heat than conventional nylon 6 molding resins.

KEY NO. 632

Other News . . .

Metals

▶ A new process for making roll formed metal parts for development projects and prototype work forms metal by a vibratory press action using flat-plate, silhouette dies that progressively fold metal strip to the required cross section. Parts are available from Prontour Co., 3490 W. 140th St., Cleveland 11, Ohio. **KEY NO. 633**

▶ A mechanically and chemically stable, sintered type 316 stainless steel filter element is designed for filtering corrosive and hot fluids. The element is marketed by Commercial Filters Corp., 2 Main St., Melrose 76, Mass. **KEY NO. 634**

Plastics & rubbers

▶ Metallized polyester film laminated to a flannel backing is designed for use on cosmetic cases, handbags, belts and other products. The decorative material can be glued, sewn, stitched and wrapped around a base material. It is available from Coat-

Coming in October . . .

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ing Products, Inc., Englewood, N. J.
KEY NO. 635

▶ A satin-weave nylon-epoxy prelar shapes and contours where good drape characteristics are required. The producer is Micarta Div., Westinghouse Electric Corp., Trafford, Pa. The prepreg, called TT-9565, is supplied in widths up to 37 in.
KEY NO. 636

Finishes

▶ A new rust preventative can be applied to steel, aluminum, copper, brass, zinc plate, galvanized sheets and magnesium to prevent corrosion during manufacturing and storage. Called Metex M-638, the material is available from MacDermid Inc., Waterbury, Conn. It can be removed by reverse current cleaning.
KEY NO. 637

▶ A new process for plating bright nickel deposits on a wide variety of metals has been announced by Metal & Thermit Corp., Rahway, N. J. Nickel sulfate, nickel chloride, boric acid and organic addition agents make up the bath solution. The process is called No. 30-W.
KEY NO. 638

Joining & fastening

▶ A new elevated temperature locknut made of Waspalloy, a nickel-base alloy, is intended for use with high performance bolting at temperatures up to 1400 F. Designated FN 1418, the one-piece self-locking nut is available from Standard Pressed Steel Co., Jenkintown, Pa.
KEY NO. 639

▶ An adhesive that forms a permanent, flexible bond between fabrics and polyurethane foam is now available from Rubba, Inc., 1015 E. 173rd St., New York 60. The adhesive, known as Rubbafab, is said to withstand washing and dry cleaning.
KEY NO. 640

▶ An economical process for welding mild steel uses carbon dioxide and a new low alloy steel welding wire. Designated A602, the wire is available from Air Reduction Sales Co., Div. of Air Reduction Co. Inc., 150 E. 42nd St., New York 17. It can be used for single or multipass mild steel applications with deposition rates varying from 7 to 15 lb per hr.
KEY NO. 641

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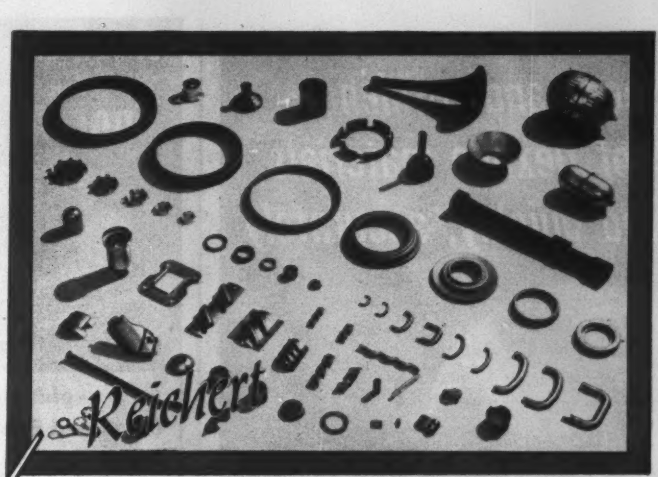

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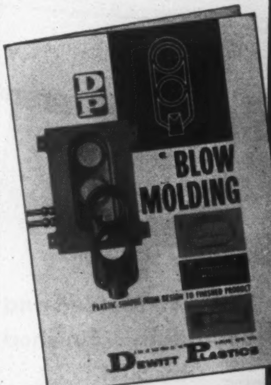

The pro's and con's of blow molding are described in DeWitt's new illustrated bulletin on blow molding. It describes its function, advantages, limitations and economies, as well as providing a handy checklist of Do's and Dont's in design to take maximum advantage of this new technique.

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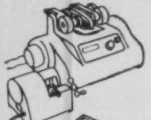

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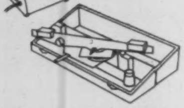

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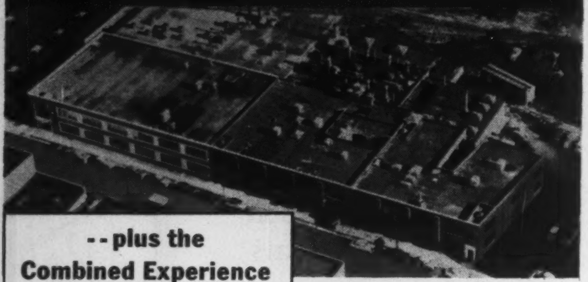

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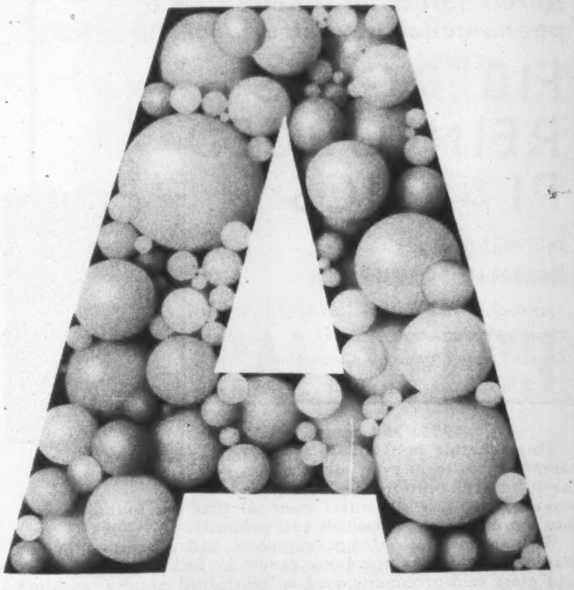

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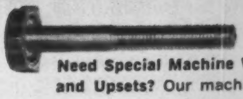

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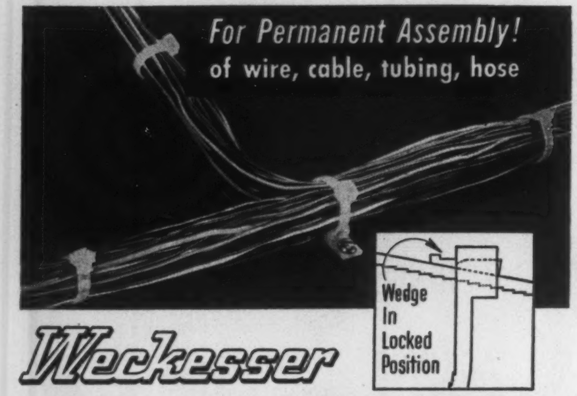

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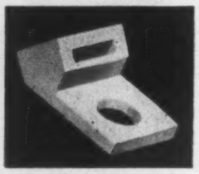

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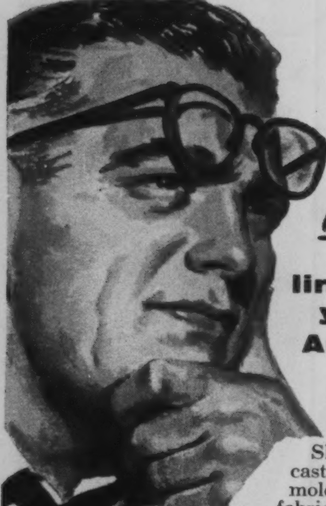

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Edited by
RALPH H. SONNEBORN

Technical Service Dept.,
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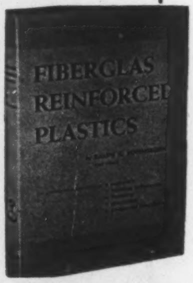

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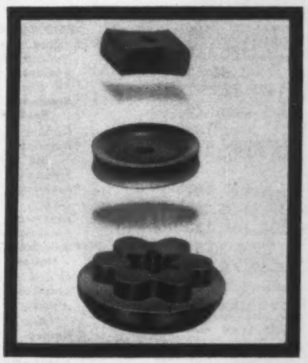

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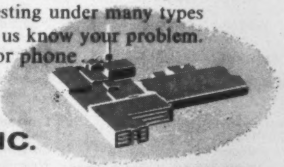

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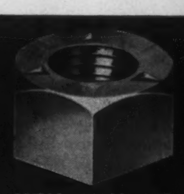

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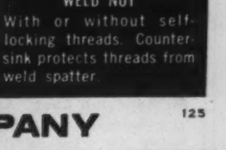

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MATERIALS SELECTOR REFERENCE DATA ISSUE

For more complete information, and application data on their lines, refer to the Index to Advertisers in the Mid-November MATERIALS SELECTOR ISSUE of MATERIALS IN DESIGN ENGINEERING.

The last word

by H. R. Clauser, editor

We Need Better Follow-Through on Research

The importance of follow-through is well known to golfers and bowlers. But the principle is no less important when it comes to applying research results to the solution of engineering problems. There is growing concern today both in government and industry that our research follow-through is not what it should be, and that the lag between original discovery and practical application is much too long.

Rocketry and ultra high pressures

There are ample grounds for this concern. Examples of our failure to capitalize on knowledge developed by researchers are many.

Perhaps the best known example—and a frightening one—was our failure in this country to realize the practical implications of Stoddard's basic work on rockets. By the early 1920's he had developed most of the basic knowledge needed for the construction of long range rockets, and almost single-handedly he tried to apply his findings. But few others in this country showed any desire to help him. It was the Germans who realized the enormous potential of Stoddard's work, and who put forth the necessary time and money to successfully translate it into practical reality—the V-1's and V-2's of World War II.

High pressure technology, the subject of a special report this month (p 111), is a more timely example. The pioneering work of P. W. Bridgman in this field began as far back as 1909. Yet, fifty years later, we can point to only one commercial application of his work: the production of synthetic diamonds. And even today, when we are more aware of the great practical potential of high pressure technology, the effort being expended is still sporadic and seems pitifully small.

On the other hand, the Russians seem to be applying the imagination and willingness required to achieve the practical breakthroughs in this field. Starting with the fund of basic knowledge developed by us, they are pushing ahead vigorously and have formed an institute in which 400 people are now concentrating on high pressure research and application.

First steps to a solution

What, then, can and is being done to more effectively translate research results into practical realities?

Confining our attention to materials alone, the government has taken a number of steps in the right direction. For example, about two years ago a materials application section was established at Wright Air Development Center. One of the group's main functions is to fill the vacuum between materials research and application. And just three months ago the government sponsored an international symposium to explore ways to more quickly apply the findings of materials researchers.

In industry, however, progress in reducing the research-application gap has not been as encouraging. Recognizing this, the American Society of Mechanical Engineers last year sponsored a project to find ways and means of shortening the road between research and application in individual companies and industries. The report of this study, titled "Ideas, Inertia and Achievement", establishes two broad principles—one for technical people and one for management people. They are:

1. Communications between basic scientists and application engineers must be improved both in and outside the individual companies.
2. Management must have and exercise the ability to ascertain the significance and importance of research results and have the willingness to take proper and prompt steps to do something about them.

At stake: 'vitality and prosperity'

Our economic future may well depend on how well these recommendations are carried out. For as the ASME report states ". . . the vitality and prosperity of a free enterprise system can be frustrated by too great a lag between discovery and application . . . every step toward shortening it—like those outlined in this study—is insurance of continued vigor in our national economy."

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Our new FREE brochure describes these multi-functional materials whose more than 850 types meet the most stringent specifications in thousands of applications. A+ Felts have ideal characteristics for absorbing, wicking, filtering, sealing, cushioning, polishing, friction, shock absorption, thermal and sound insulation, padding, surfacing, vibration isolation, percussion control and decoration.

Send today for your personal copy of this practical guide to A+ Felts . . . the problem-solving engineering and design material.

American Felt Company

American Felt Company
is A+ in
- **SERVICE**
- **QUALITY**
- **ENGINEERING and RESEARCH**

For more information, turn to Reader Service card, circle No. 475

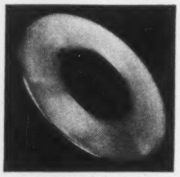
Umbrella maker gets 40% savings from Graph-Air®

Their umbrellas are easy to raise and sell, but Newark Umbrella Frame Co. had troubles holding their tool costs down. The high-carbon, high-chromium tool steels used to form the ribs and to stamp the catches didn't machine easily. Rolls and punches made of these steels wore out prematurely. Punches often chipped and broke.

Timken Company metallurgists studied the problem. Recommendation: switch to Graph-Air® tool steel. Results: roll life went up 40%; punch life tripled. Here's why.

Graph-Air machines easier than other tool steels because of the free graphite in its structure. It outwears other tool steels by as much as *3 to 1* because of the uniformly hard carbides in its structure. It air-hardens at 1450°—as much as 450° *below* most other air-hardening tool steels, reducing dimensional change, simplifying heat treating. And Graph-Air holds its accuracy longer because it's one of the Timken graphitic tool steels, the most stable made.

Let Timken Company metallurgists help solve your steel problems. They've been solving tough ones for over 40 years. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.



Forming roll life upped 40% with Graph-Air tool steel.

Graph-Air tool steel triples life of this punch.

TIMKEN® FINE ALLOY STEEL

TIMKEN GRAPHITIC STEELS ARE AVAILABLE FROM STEEL SERVICE CENTERS IN 44 CITIES IN THE UNITED STATES AND CANADA

For more information, turn to Reader Service card, circle No. 321